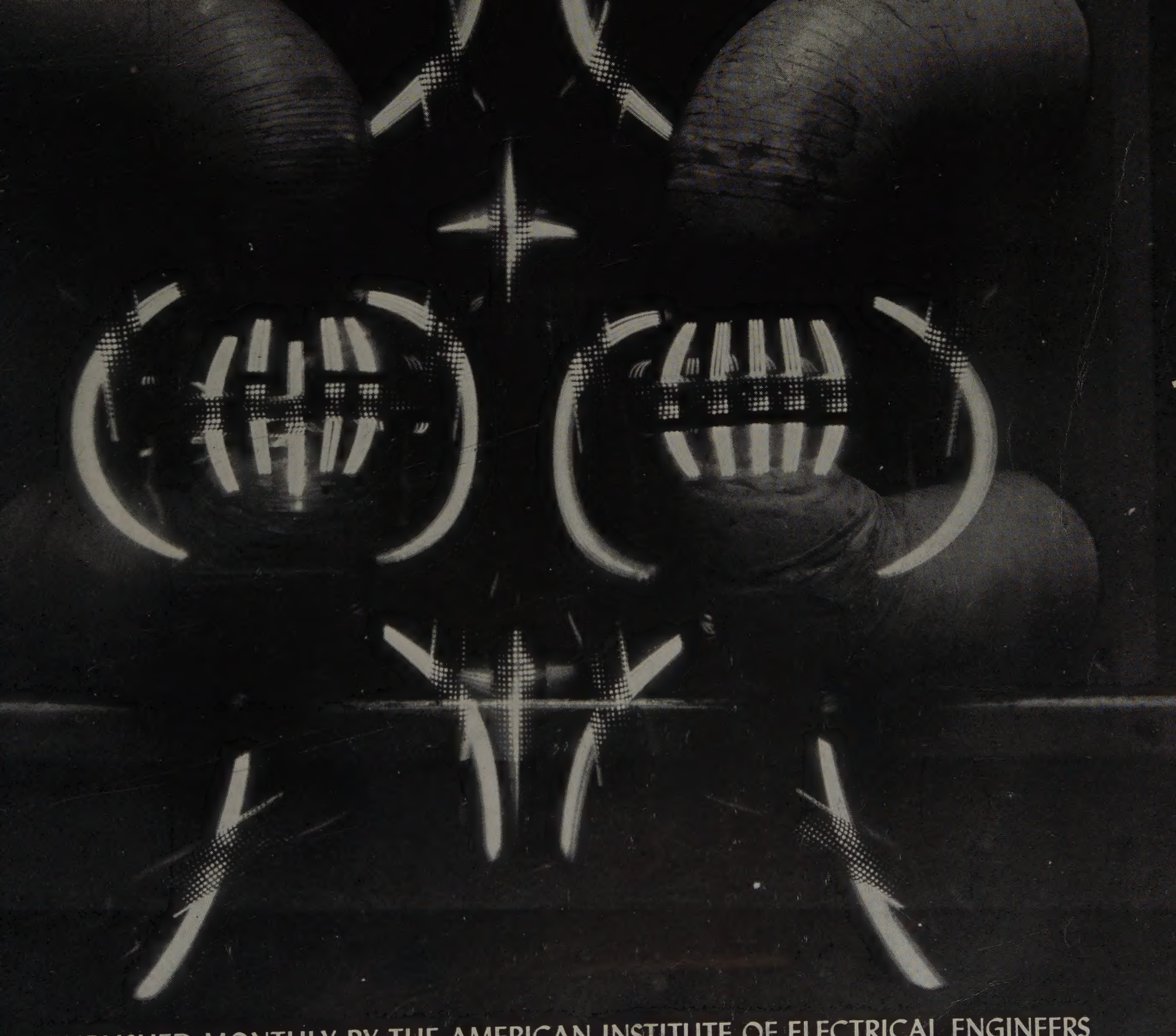
ELECTRICAL ENGINEERING

DECEMBER 1948



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1948

The Cover: Magnetic field map obtained by successive exposures. The electron tube used for mapping this field is described in an article in this issue (*pages 1143–4*).

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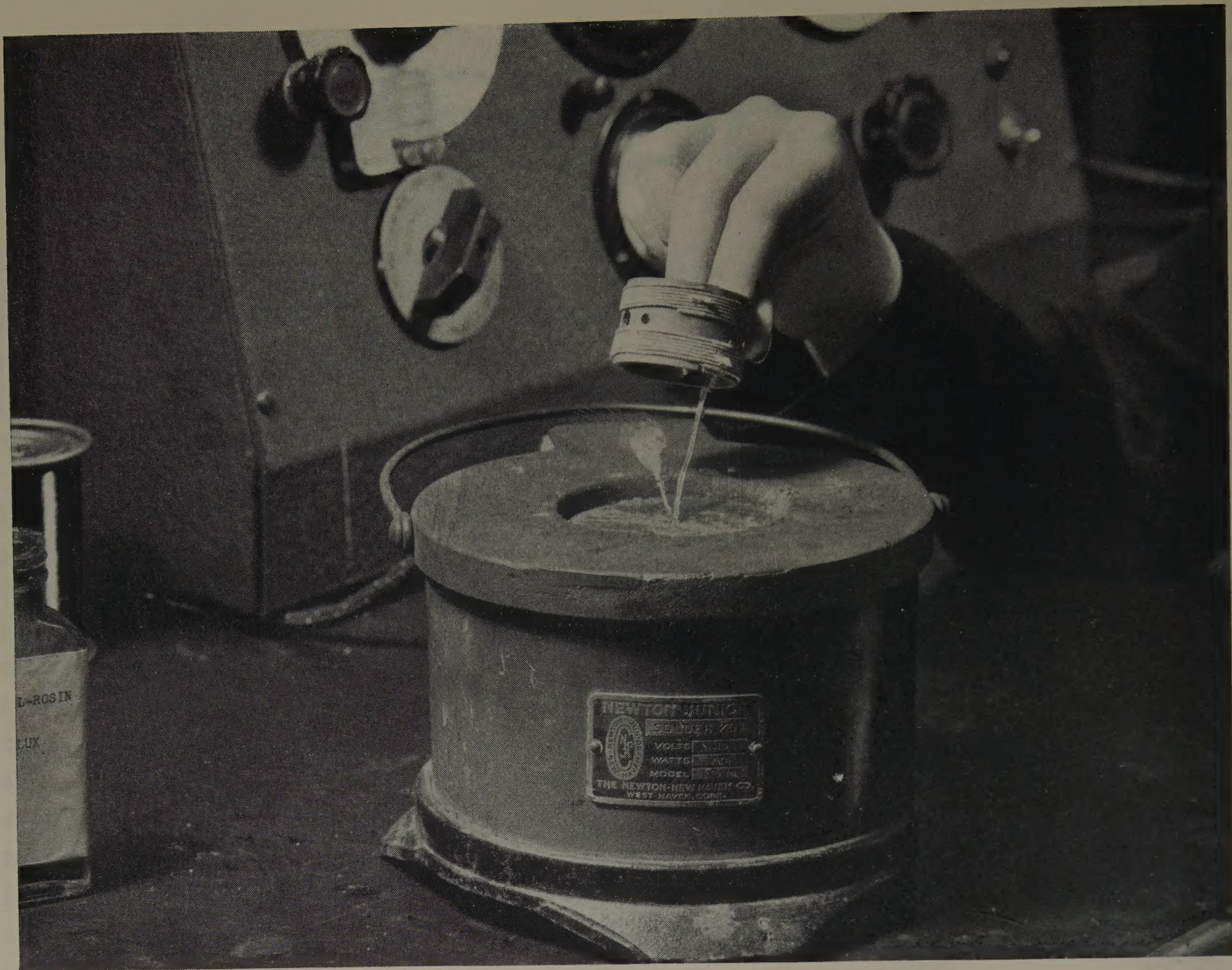

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WIREMAKER FOR INDUSTRY

HIGHLIGHTS........

Information for Authors

A revised edition of the "Information for Authors" booklet now is available to all prospective authors. Suggestions are given for the preparation of papers in standard form, both for presentation at meetings, as well as for special articles for ELECTRICAL ENGINEERING. To obtain a copy for the preparation of a technical program paper, write to: Secretary, Technical Program Committee, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y. To obtain a copy for the preparation of a broad article of general interest for publication in ELECTRICAL ENGINEERING only, address request to: Editor, ELECTRICAL ENGINEERING, AIEE Publications Department, Suite 7–8 Lower Level, 500 Fifth Avenue, New York 18, N. Y.

AIEE PROCEEDINGS. The fourth order form for 1948 AIEE *PROCEEDINGS* appears in this issue (*pages 35A–36A*). It covers papers presented at the Midwest general meeting and at the Southern District meeting in Birmingham, Ala., November 3–5. Members interested in obtaining *PROCEEDINGS* sections already published are referred to the AIEE *PROCEEDINGS* box for information (*page 1209*).

New AIEE Publication. A new AIEE publication now is available from the AIEE order department: A report on "Electrical Engineering Problems in the Rubber and Plastics Industries." The report includes papers presented at the AIEE Conference held in Akron, Ohio, April 20, 1948 (*page 1214*).

Planning for Power Supply. Changes in population as well as increased use of electric power, both industrial and residential, are factors to be considered in any long-range plan for power supply. According to a study in this issue, present conditions indicate that in the United States coal will continue to be the most important single resource for the future development of power until atomic energy, or some other source of energy not now used, is developed (*pages 1135–41*).

Seeing Magnetic Fields. Tubes have been built which give observers the impression of seeing magnetic lines of force. These tubes are mercury-vapor diodes with perforated or slotted anodes. Low-velocity electrons are focused magnetically nto tight helical beams whose axes follow the magnetic flux paths quite accurately. Some interesting photographs of magnetic field patterns, one of which appears on this month's cover, are possible using these tubes (*pages 1143–6*).

Engineering Careers. "Engineering is an expanding field of activity which continually calls for broader backgrounds to cope with new problems. It is also a career which presents opportunities for men with widely different backgrounds and widely different abilities, provided that they have the basic requirements for the profession" (*pages 1146–7*).

Rural Distribution Voltages. A higher distribution voltage for use in rural areas definitely is needed where farms are widely scattered and where the kilowatt-hour consumption will be substantial. A change to 23,900/13,800 volts Y with multigrounded neutral appears to offer the best solution in some areas (*pages 1191–3*).

Mathematics for Engineers. Dimensional analysis of partial differential equations provides the subject for the third and concluding part of a series discussing mathematics for engineers. The articles in this series will be made available in pamphlet form (*pages 1185–8*).

Unsolved Power Problems. "The power industry has a bright future but the success of the industry depends on the men attracted to it"—and today's engineering graduate is much more interested in the newer fields of communications and electronics. The author, deploring this trend, points out that there are still many unsolved problems in the power field to challenge the resourcefulness of the young engineer who might be overlooking the opportunities to be found in this oldest branch of the electrical industry (*pages 1162–5*).

Canadian Engineer in Scandinavia. The author, a Canadian hydroelectric engineer who visited Norway and Sweden in 1947, presents his observations of the power situation in those countries and finds that they depend almost entirely on the utilization of water power. Both nations have large hydroelectric construction programs under way, in answer to increased demand, and Norway has the additional problem of repairing damage inflicted by the German occupation forces when they evacuated northern Norway in 1944 (*pages 1169–82*).

Reverse Blowout Effect. "Because pressure of the gas plays an important part in the determination of the characteristics of the (electric) discharge, arcs are classified into three groups: high-pressure arc (above atmospheric pressure), atmospheric arcs, and low-pressure arcs (below one millimeter of mercury)." The problem considered in this article deals with the atmospheric arc with pressures ranging down to one centimeter of mercury (*pages 1148–52*).

Electrical Prerotation. With the advent of very large aircraft, landing wheel prerotation may be considered seriously as economically feasible. It has been trouble-free so far, has proved satisfactory on limited test, and offers at least three advantages: improved tire life, more comfortable landings, and, most important, reduction of structural loads (*pages 1154–9*).

Digests. A number of papers presented at the 1948 AIEE Middle Eastern District meeting are digested in this issue. This meeting was held in Washington, D. C., October 5–7 (*pages 1142, 1153, 1160, 1161, 1166, 1167, 1168, 1183, 1184, 1189, 1190*).

Corrections. The following correction should be made in the digest, "Tests at 500-Kv Station at Chevilly," by François Cahen, which appeared in the October issue, page 972. In the second column, fourth paragraph, the fourth line should read " . . . in direct proportion to $\delta 2/3$, . . ." instead of ". . . in inverse ratio to $\delta 2/3$, . . ." . . . A correction also should be made in the footnote of the article, "Origin of the Electric Motor," by Joseph C. Michalowicz, which appeared in the November issue, pages 1035–40. The statement that the article is not scheduled for publication in AIEE *TRANSACTIONS* should be corrected to read, "Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948."

News Index

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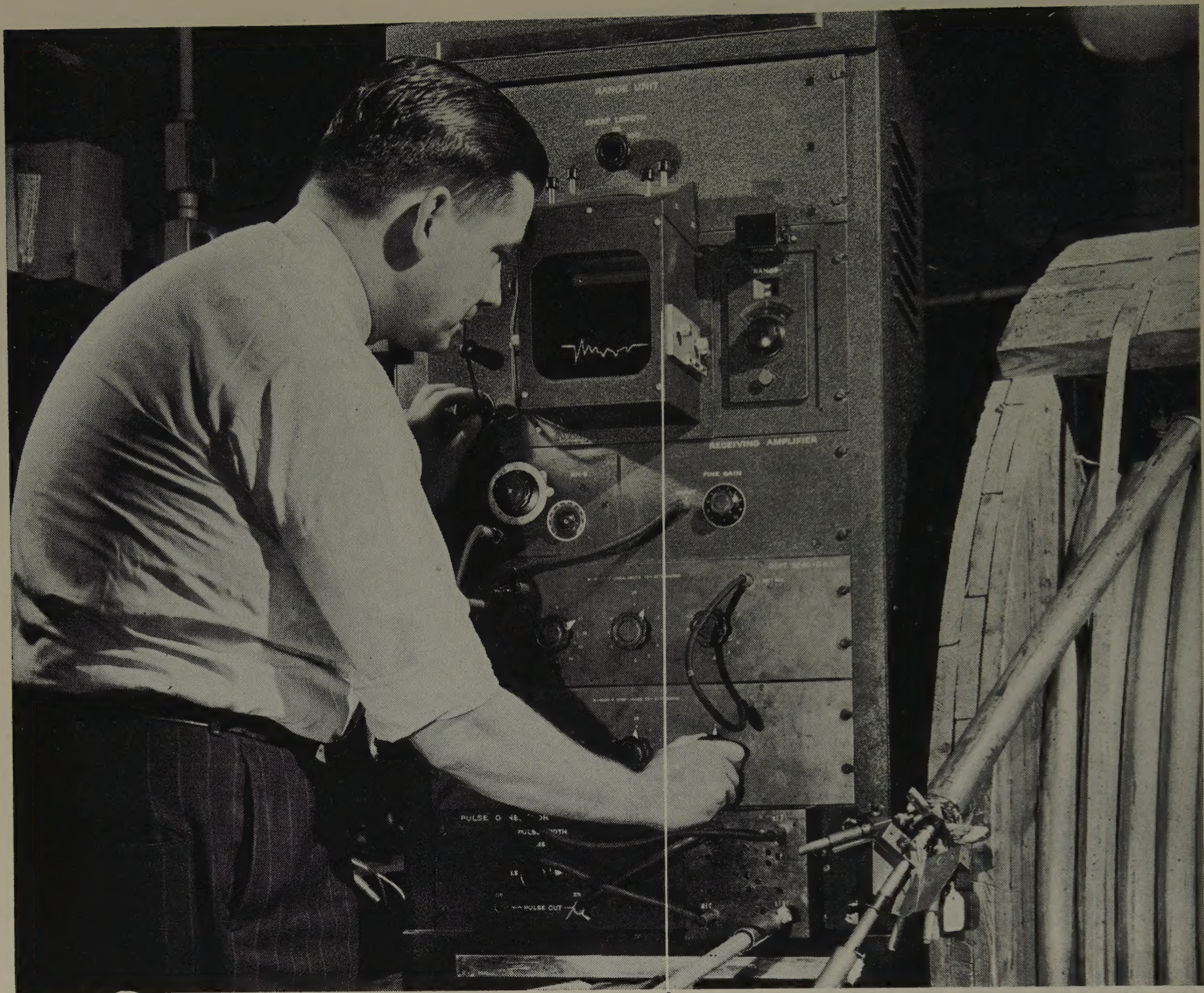

Long-Range Planning for Power Supply

F. O. McMILLAN
FELLOW AIEE

The problem of long-range planning for power supply is one which is generally recognized by planning engineers, and one which must take into account a number of factors ranging from population changes to expected sources of supply. This article reviews and considers some of the most pertinent data, and an attempt is made to arrive at some general conclusions regarding such planning in the light of present-day conditions.

AT THE BEGINNING I wish to make it clear that I am suffering from no illusion that I can look deeper or see the future more clearly than others by crystal gazing. To see how deceptive looking into the future may be, one has only to recall that as recently as 1945 the electrical industry was conducting research and planning load building programs to provide load for the "excess" capacity that was expected to become available due to the loss of war industries. This load building program scarcely was started when the entire industry realized that it was being overwhelmed by the greatest demand for electric energy it ever has experienced. The realization of the deluge that was upon the industry started the present race with time in an attempt to keep the generation, transmission, and distribution facilities abreast of the load requirements. Failure in this race in certain areas made it necessary to curtail and discourage load growth in an effort to maintain service until such time as the building of facilities can keep pace with the load demand.

There are some who object to the extrapolation of historical data in the form of curves into the future because changing conditions may greatly alter the factors that control trends in almost every field of endeavor. However, the fact remains that factual historical data constitute the only foundation on which we can build experience to guide us in planning for the future. In fact, as has been so well stated, "to see where we are going is the only reason to look back."

The volumes of accumulated data available on the electrical and related industries would be very useful in a lengthy consideration of the subject of long-range planning for electric power supply. However, in this short discussion of the subject only a small segment of the pertinent data can be reviewed and considered. Therefore most of the data presented will consist of historical records prepared in graphical form, from which one can arrive at some conclusions regarding long-range planning for power supply.

POPULATION GROWTH

The population served is an important factor in determining power requirements, therefore, the total population and population trends must be considered. As shown in Figure 1, the population of the United States, as a whole, increased from 3.93 million in 1790 to 132.5 million in 1940, and estimates place the 1950 population at 144.7 million. The per cent gain in population in each decade over the preceding census varies from 26.6 per cent to 40.5 per cent at which value it became a maximum in 1840 and then declined to a minimum of 7.9 per cent in 1940. The estimated gain in population in 1950 over 1940 is 9.2 per cent. The rate of population growth for the United States as a whole probably will not exceed 10 per cent per decade within the next two or three decades.

While the population of the nation as a whole has settled down to a moderate rate of gain, throughout its history there have been very violent fluctuations in regional population caused by migrations. Two areas, the Pacific Coast and the Gulf Coast, now are experiencing very rapid growths in population because of migration. Most industrial areas also have shown marked increases in population during the past decade when industrial production has been at a high level.

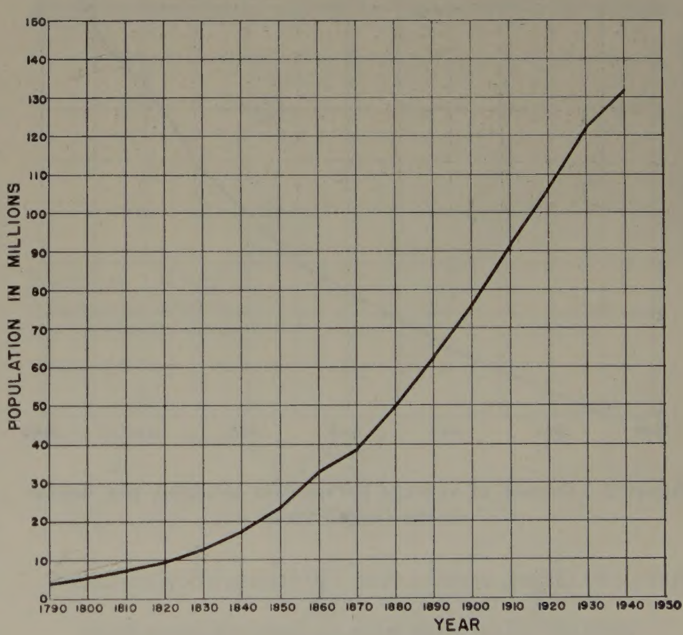

Figure 1. Growth of population in the United States from 1790 to 1940

These rapid regional changes in population because of migration have a very important influence on power requirement and the basic underlying causes of the population

Essentially full text of an address presented at the AIEE Pacific general meeting, Spokane, Wash., August 24–27, 1948.

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shifts should be observed in advance and used as a basis for anticipating the necessary increase in power supply.

ELECTRIFICATION OF INDUSTRY

Since the beginning of the industrial development of America around 1850 power used by the industrial worker has been constantly increasing. Along with this mechanization of industry there likewise has been an unprecedented industrial growth and a corresponding increase in the number of workers employed. In 1850 there were 7.4 million workers employed, and in 1940 the number had increased more than six times to 46.9 million. At the peak of war production the number reached 63.2 million, and the present number is probably near 60 million. There was very little power available to the worker in 1850; but in 1947 there was an average of 7.2 horsepower per worker (Figure 2) and the amount per worker had more than doubled since 1915. The present trend indicates that by 1960 the horsepower per worker will approach 10.

At the beginning of the period of industrial development in 1850 there was no electric power, but now more than 90 per cent of industrial power is electric. In the period of four years from 1939 to 1943 the industrial use of electric energy more than doubled when it increased from approximately 80 billion to more than 160 billion kilowatt-hours.

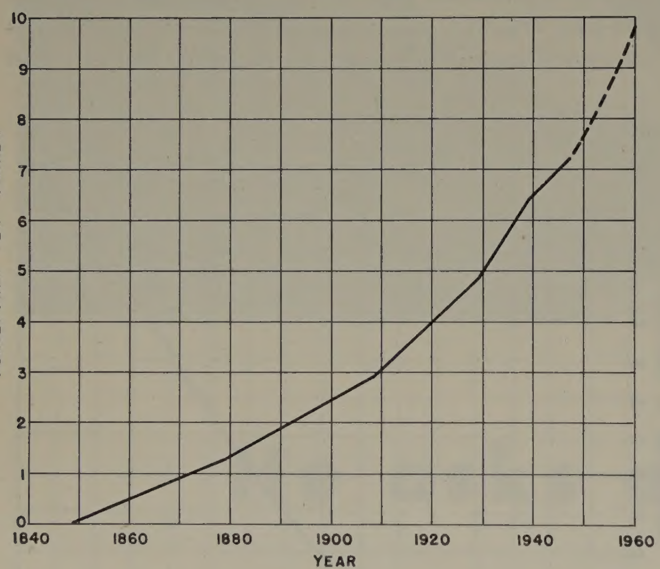


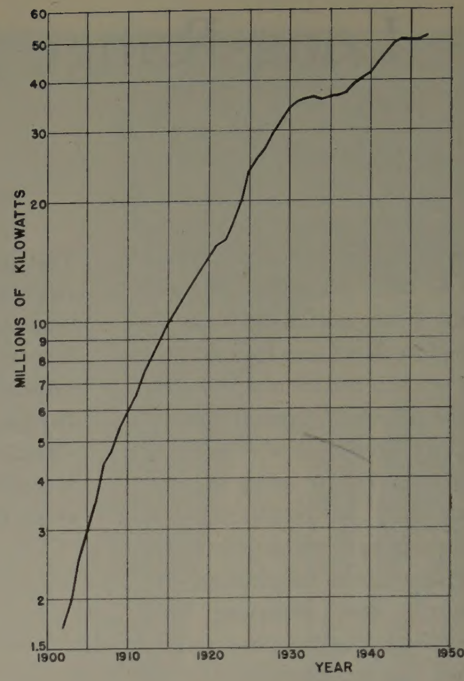
Figure 2. Growth of average horsepower available per worker in the United States

RESIDENTIAL AND RURAL ELECTRIFICATION

In the 10-year period between 1937 and 1947 the average energy consumption per residential customer in the United States increased from 805 to 1,438 kilowatt-hour, or almost 79 per cent. This is a large increase, but the present national average is less than one-half the use in some areas. Without doubt, the domestic use of energy will continue to grow rapidly, and when the heat pump is perfected and reduced in cost by mass production for residential use, there will be a very marked increase.

Approximately 90 per cent of the farms in the United States now have electric service available but the use of energy is relatively very small. The average use in 1947 was 2,182 kilowatt-hours, or only 52 per cent greater than the average residential use. Therefore, it is apparent that the farm use of electric energy will grow rapidly as the newly electrified farms are able to procure equipment, and as new equipment is developed to meet farm requirements.

Figure 3. Growth in kilowatts of installed capacity in the United States



INSTALLED GENERATING CAPACITY

The historical record of the installed generating capacity of the electrical utilities shows that in 1902 there were 1.7 million kilowatts, and that by 1947 the figure had grown to 51.6 million (Figure 3). From 1920 to 1947, the period over which reliable records are available showing the types of prime movers, the relationship of the capacity of fuel plants to hydro plants on a percentage basis changed very little. In 1921 fuel plants represented 74.5 per cent and hydro plants 25.5 per cent of the total generating capacity. This was the year of maximum steam capacity and minimum hydro capacity. In 1945 fuel plants represented 70.3 per cent and hydro plants 29.7 per cent of the total generating capacity. It was during 1945 that hydro capacity reached the highest percentage and steam capacity the lowest on record. (Figure 4.)

Some persons well acquainted with electric power trends estimate that the generation requirements for the nation as a whole will be approximately twice the present capacity, or 100 million kilowatts, by 1960; others are more conservative. If the value of 100 million kilowatts is accepted for purposes of discussion and the present approximate ratio of 70 per cent fuel and 30 per cent hydro plants is assumed to be maintained, it means that 33 million kilowatts of fuel plants and 15 million kilowatts of hydraulic plants must be built in the period between 1948 and 1960. This means that an average construction rate of four million kilowatts per year for 12 years must be maintained just to meet the requirements for load growth and without any provision for equipment retirement. These figures appear fantastic, and they may be; but in the opinion of some they are entirely within the realm of possibility.

ELECTRIC ENERGY GENERATED

In 1902 the energy generated was two billion kilowatt-hours; in 1947 it had increased to 255.4 billion. In the ten-year period between 1937 and 1947 the generated energy more than doubled. Graphs of the historical energy data for the United States, for the Northwest Power Pool, and for the western group of the Northwest Power Pool are all very similar (Figure 5). This indicates that, in general, the same factors influence the energy requirements over the entire country but there are also local contributing conditions. The low cost of energy in the Northwest attracted the aluminum reduction plants which have caused a very rapid rise in energy consumption.

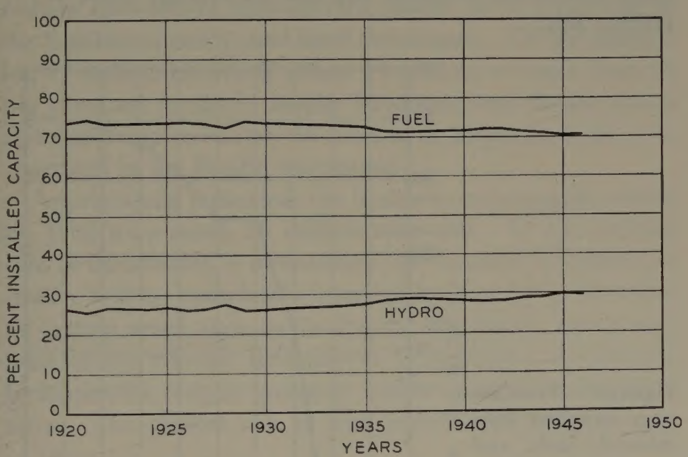


Figure 4. Comparison of fuel and hydro generating capacity in percentages of total generating capacity

SOURCES OF ENERGY

If anthracite and bituminous coal are segregated and sub-bituminous coal and lignite are included under bituminous coal, there are five sources of energy now available and economically feasible for power generation. They are

1. Water power.
2. Anthracite coal.
3. Bituminous coal.
4. Crude oil.
5. Natural gas.

Over the years these sources of energy have been used in varying amounts. In 1899 water power contributed 3.2, anthracite coal 21.8, bituminous coal 67.3, domestic crude oil 4.5, and natural gas 3.2 per cent of the total heat energy. Forty-five years later, in 1944, water power contributed 3.9, anthracite coa' 5.2, bituminous coal 48.3, domestic crude oil 29.9, imported crude oil 0.8, and natural gas 11.9 per cent of the total heat energy. (Figure 6.)

The percentage contribution to the total energy requirements has been quite constant for water power; anthracite coal has decreased materially; bituminous coal has decreased appreciably; domestic crude oil has made a very large increase, especially since 1918; imported crude oil is just beginning to contribute energy; and natural gas contributed an almost constant percentage until 1923 when it began growing rapidly.

Other sources of energy that may become important as present sources are depleted or as they increase in cost because of inaccessibility or other reasons are

1. Oil shale.
2. Wind power.
3. Direct radiation from the sun.
4. Atomic energy.

An estimate by Winchester places the amount of oil recoverable from shale at 92 billion barrels. This is nearly twice the sum of the 30 billion barrels that have been produced since 1859 and the 20 billion barrels of proved reserve still in the ground. The production of oil from shale is entirely feasible, but past oil values have not justified such production.

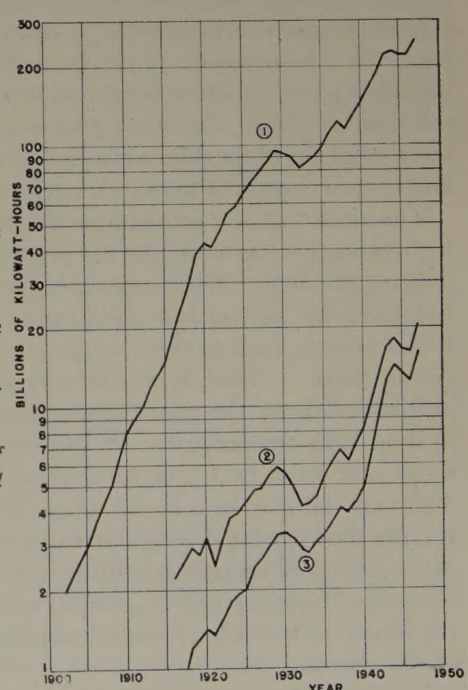
Wind power was investigated in the United States by a group of scientists and engineers during the period from 1934 to 1945. These investigations led to the design, construction, and actual operation of a 1,250-kva unit on the system of the Central Vermont Public Service Corporation from March 3 to March 26, 1945. After 143 hours and 25 minutes of operation, during which time 61,780 kilowatt-hours of energy were generated and delivered to the system at an average load of 431 kw, operation was interrupted by the failure of one of the air turbine blades. The mechanical weakness that resulted in the blade failure was susceptible to correction. Nevertheless, it was concluded that at the costs prevailing in 1945 and under the conditions in Vermont the total warranted investment for a 9,000-kw wind-power development would be about $125 per kilowatt while the actual cost would be about $205 per kilowatt at the point of connection to the utility system, therefore, such a plant was not economically justified. The investigations were financed by the S. Morgan Smith Company at a cost of more than $1^1/_4$ million dollars and are described fully in the book, "Power from the Wind," by Palmer C. Putnam.

Figure 5. Electric energy generated in the period 1900–47

1—United States as a whole

2—Northwest Power Pool

3—Western group of Northwest Power Pool



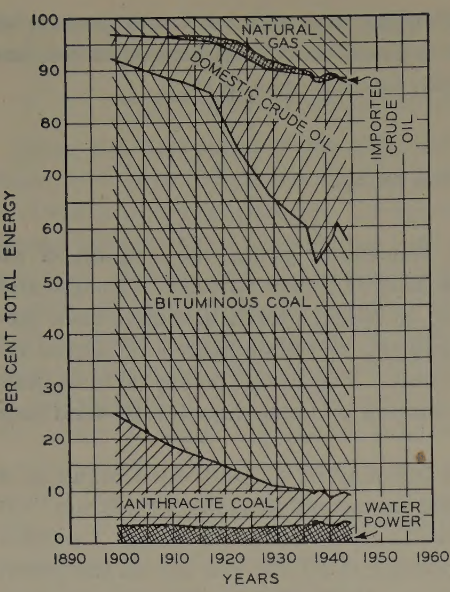


Figure 6. Sources of energy in the United States

the technical problems are formidable and the economic questions involved are still more baffling. Most of them predict that atomic power is at least 20 years in the future.

Direct radiation from the sun has been utilized in many ways, and much effort has been directed toward absorbing the radiant energy in sufficient quantity and at a sufficiently high temperature to be useful as a source of power. Up to the present time these efforts have not resulted in an economical method of producing power.

It appears to be the consensus of the Atomic Energy Commission and those responsible for research in the field of atomic energy that a "power pile," or nuclear reactor, can be built to operate at a temperature high enough to produce useful power. No means yet has been devised to convert atomic energy directly to electric energy. Therefore, it will be necessary to use fissionable uranium 235 or plutonium, each of which is capable of maintaining a chain reaction, as "fuel" to produce heat energy which must be transferred out of the pile, converted to mechanical energy, and in turn converted to electric energy.

The transfer of heat energy from the pile at a temperature high enough to be useful for the production of power is a difficult problem. When materials are subjected to bombardment by the nuclear disintegration products of the fission process, some of them are greatly altered in physical characteristics. Thus, it may be very difficult to find suitable materials for the pile heat exchanger when it is operated at high temperature. A suitable heat-transfer material also must be found to circulate through the pile. This material may be a liquid metal, or a gas. The heat-transfer fluid passing through the reactor will become radioactive; this will necessitate putting it through another heat exchanger to give up its heat, possibly to water, thus generating steam, with which a conventional steam turbogenerator can be driven.

The protection of personnel from radioactivity is a major problem requiring massive barriers and elaborate remote-control and material-handling equipment. Very thorough periodical physical examinations are also necessary. The ingestion of microscopic quantities of some of the radioactive substances may prove fatal.

Reports by those in a position to know about the use of atomic energy for the generation of electric energy in competition with existing steam and hydraulic plants state that the technical problems are formidable and the economic questions involved are still more baffling.

ENERGY REQUIREMENTS

The total annual energy requirement from mineral fuels and water power in the United States grew from 4.4 quadrillion Btu in 1889 to 22.2 quadrillion in 1920 (Figure 7). After 1920 the average annual rate of increase in energy consumption decreased quite abruptly to an average annual value of 167 trillion Btu per year. In fact, during the period after 1920 the energy consumption per capita became practically constant and had an average value of 197 million Btu.

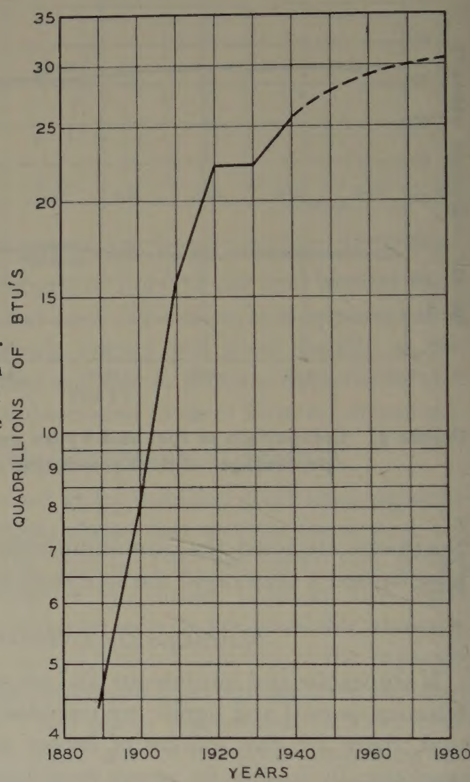


Figure 7. Total energy supplied from mineral, fuels, and water power in the United States

The improvements in the energy-consumption trend after 1920 are directly attributable to increases in the efficiency of recovering the heat energy from fuel. Some of the important contributing factors were large increases in steam pressures and temperatures (Figure 8), together with improved methods of firing and burning fuels. Increases in energy consumption stem largely from three causes:

1. Expansion and mechanization of industry.
2. A rising standard of living.
3. Developments to accommodate the increased population.

These factors are all still active and it is difficult to know how long technological developments will make it possible to keep the annual energy requirements per capita at the nearly constant level maintained since 1920. It would appear that this energy level could be maintained or lowered because of the reduction in fuel requirements per kilowatt-hour that now is assured in the electrical utility field, which is leading all other industries in fuel economy. The average fuel consumption for all electrical utilities in 1947 was 1.3 pounds of coal per kilowatt-hour (Figure 9), which is a thermal efficiency of approximately 20 per cent. The most

efficient plants were operating at a thermal efficiency of 34 per cent or better. If and when the electric power industry, as a whole, attains the present best efficiency, the resulting reduction in the fuel requirement per kilowatt-hour will be 41 per cent. Other industries now operating with poorer fuel economies should be able to effect even greater savings.

ENERGY RESERVES FOR FUTURE DEVELOPMENT

The hydroelectric power resources of the United States that are considered at present to be feasible for development from an engineering and economic standpoint amount to about 54 million kilowatts. In December 1947, 14.8 million kilowatts of hydroelectric power, or 27.5 per cent of the feasible capacity, had been developed. Of the remaining 39 million kilowatts, about 24 million, or more than 60 per cent, are in the 11 Rocky Mountain and Pacific Coast states and approximately 14 million, or 36 per cent, are concentrated in the Pacific Northwest.

As previously indicated, the hydroelectric capacity added by 1960 may reach 15 million kilowatts. If this average rate of installation is maintained, the feasible hydroelectric reserve will be completely installed in from 30 to 40 years. In certain areas, such as the Pacific Northwest, where very little or no mineral fuel reserve is available, the feasible hydroelectric reserve probably will be installed in a shorter time. The present rate of load growth and planned con-

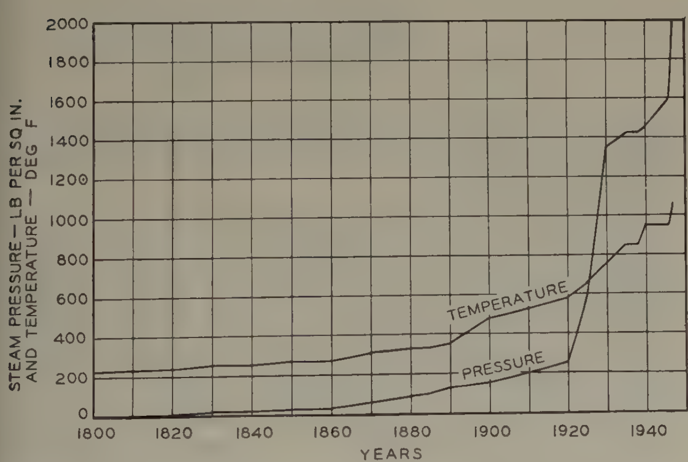


Figure 8. Steam pressures and temperatures for prime movers

struction indicate that the hydroelectric reserve in the Pacific Northwest may be completely installed in approximately 20 years.

Coal will continue to be the most important single resource for the future development of power for at least 20 years unless atomic energy proves to be available earlier and to be more economical than now anticipated. The United States has about one-half of the known coal reserves of the world; of the 48 states, 22 have reasonably large reserves.

The estimated original reserves of anthracite coal were 24 billion tons, and in January 1944, the remaining reserves were 15.7 billion tons, or 65.5 per cent of the original reserves.

In January 1944 the estimated remaining reserves of bituminous coal, subbituminous coal, and lignite in continental United States were 3.1 trillion tons. At the maximum annual rate of production in the past—658 million tons in 1920—and with the prevailing mining losses of 34.7 per cent of the coal in the ground, or 53.14 per cent of the coal produced, this reserve would last approximately 3,100 years.

The total coal resources in Alaska are estimated to be 110 billion tons, but at the present, because of high costs of mining and shipping, Alaska coals are important only for use in the territory.

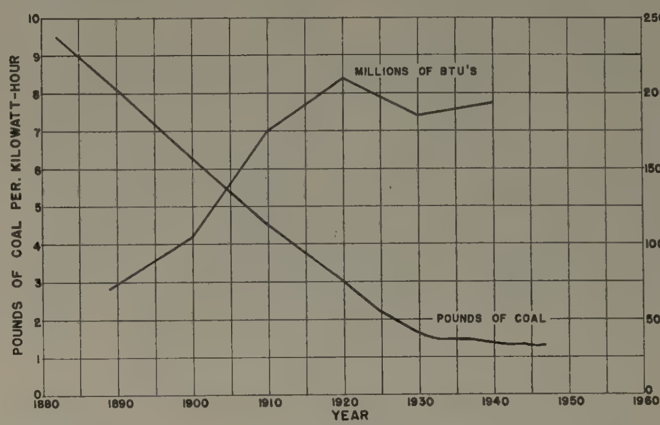
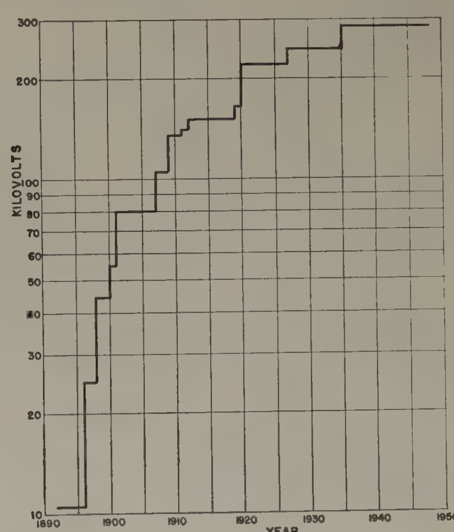


Figure 9. Average pounds of coal per kilowatt-hour and energy consumption per capita for the United States

High mining losses (34.7 per cent) and increased cost of production, which results from many causes, including the fact that in general the coal deposits that were most economical to work have been mined first, have stimulated interest in the underground gasification of coal in place.

Figure 10. Maximum transmission voltages in the United States



This is not a new idea, having been suggested by Professor Mendeleev as early as 1888, but the first serious research on the subject in the United States was undertaken jointly by the Alabama Power Company and the United States Bureau of Mines at Gorgas, Ala., in 1946 and 1947.[1,2] The results obtained were very encouraging and another experiment is planned for the future. These experiments may result in an economically efficient method of extracting the energy from coal in place by burning the gas obtained either under boilers or in gas turbines.

Crude petroleum is becoming more and more costly to find, not entirely because of the inflationary rise in costs but also because of the increasing difficulty and effort required to bring in a producing well. The depths of producing wells in the Southwest have increased from 3,400 to 4,000 feet in ten years with increasing number of wells reaching depths of from 12,000 to 14,000 feet. Drilling costs have increased from about $22,000 to $86,000 per well. Open-water wells on the Pacific and Gulf coastal shelves may require a drilling platform costing up to $1,200,000 before drilling can be started.

The petroleum resources of the United States, discovered and developed, total about 50 billion barrels, comprising 30 billion barrels produced at the end of 1944 and 20 billion barrels of proved reserves. At the end of 1945 the American Petroleum Institute estimated the proved petroleum at 20.8 billion barrels. This shows that additions to proved reserves more than equalled the depletion in 1945. The amount of undiscovered petroleum cannot be estimated.

The future outlook for low-cost fuel oil for power generation is not good.

UTILITY PHYSICAL PLANT

The distribution of investment between the various functional classifications of physical plant for the class *A* and class *B* privately owned public utilities of the United States is:

Physical Plant	Per Cent
Production	
Steam	25.27
Hydraulic	10.43
Internal combustion	0.33
Total production	36.03
Transmission	15.33
Distribution	41.66
General	4.18
Unclassified	2.80
Total physical plant	100.00

Production plant equipment for electric energy generation will continue to be driven primarily by hydraulic and steam turbines.

Hydraulic turbines have attained efficiencies well over 90 per cent, hence very little gain in efficiency can be expected.

As shown in Figure 8, steam boiler and turbine pressures and temperatures have been increased rapidly since 1920 and they still are continuing the upward trend. Improved methods of burning fuels and extracting the heat energy, together with these increases in steam pressures and temperatures, has raised the over-all efficiency of the most efficient steam plants to 34 per cent or more, and further improvements are being made.

Transmission voltages were increased relatively rapidly during the early years of high-voltage transmission-line development, reaching 220 kv in 1920. In the 28 years since 1920 the maximum transmission voltage only has increased 67.5 kv, bringing the maximum to 287.5 kv (Figure 10). Further increases in transmission voltage will be made, no doubt, but there is strong indication that, while technically much higher voltages are feasible, the point of diminishing return from an economic standpoint is being approached.

The distribution plant represents the largest investment in any of the functional classifications of utilities, yet in the past it has not received engineering and management attention commensurate with the investment and its importance in the over-all functioning and efficiency of the system as a whole.

Copper is the sinew of the electric system. It is especially important in electric machinery and equipment because of its relatively low cost and high conductivity with resulting small space requirement. Copper has the highest electrical and thermal conductivity of all the metals, other than silver. These characteristics make it especially important in electrical and thermal applications. Approximately one-half of the metallic copper consumed in the United States is used for electric equipment.

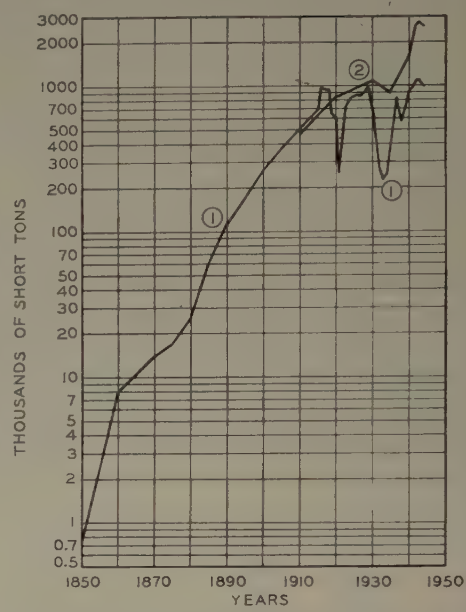


Figure 11. Copper output from domestic ores and consumption in the United States

1—Domestic copper output

2—New and old copper consumption

The copper reserves in the United States are being depleted at a rapid rate (Figure 11). If the conditions that prevailed in January 1944 had continued, the estimated available reserve probably could have supported production at an annual rate of about 1,000,000 tons for nearly ten years, after which the supply would have declined until virtual exhaustion of the estimated reserve in 30 years. At that time the price of copper was quoted at 12 cents per pound for electrolytic grade delivered, Connecticut Valley; actually the price to the miner ranged from 12 to 27 cents as a result of government premiums in the form of subsidies to mines for producing in excess of certain previous rates of production.

The current 1948 rate of copper use indicates that there will be an annual copper deficit of some 500,000 tons according to some sources. This is about 50 per cent of the peak production from domestic ores. Apparently the deficit can be made up only by importing copper, and to encourage such imports, Congress has suspended the copper import tax.

The copper situation is serious enough to warrant taking all reasonable conservation measures and also to strive to increase domestic production from ores that are not now economical to process. Some measures that will aid in copper conservation are: substituting other materials where satisfactory, giving more attention to distribution system design, increasing distribution voltages, and correcting power factor.

SUMMARY

1. National changes in population probably will be of the order of ten per cent or less per decade.

2. Regional changes in population are large in some areas, amounting to more than 40 per cent in eight years.

3. The power used per industrial worker is growing rapidly and may reach ten horsepower by 1960.

4. Residential and rural use of energy is growing rapidly with no indication of saturation because the use in some areas is at present two or more times the national average.

5. Load growth indicates that the 1947 generating capacity may have to be doubled by 1960.

6. The percentages of fuel and hydro generating capacity have remained quite constant over the years and are now approximately 70 per cent fuel and 30 per cent hydro.

7. The electric energy generated is increasing at a very rapid rate having more than doubled in the decade from 1937 to 1947.

8. The only sources of energy now available are

(*a*). Water power.
(*b*). Coal.
(*c*). Crude oil.
(*d*). Natural gas.

9. Improvements in the thermal efficiency of boilers and turbines since 1920 have had a marked effect on the total national energy requirements.

10. The feasible hydroelectric reserve in the United States probably will be completely developed in the next 30 to 40 years. The Pacfiic Northwest reserve may be developed in as short a period as 20 years.

11. Coal will continue to be the most important single resource for the future development of power until atomic energy or some other source of energy, not now used, is developed.

12. The United States has one-half of the coal reserves of the world These reserves are estimated to be sufficient to last 3,100 years at the maximum annual use attained to date.

13. The gasification of coal in place gives promise of eliminating mining losses and effecting a material reduction in the cost of extracting the energy from coal without removing it from the natural beds

14. Transmission voltages probably will go to higher values, but we appear to be approaching the point of diminishing returns from an economic standpoint.

15. Distribution plant needs more engineering and new ideas to reduce investment and improve efficiency.

16. The national copper supply is approaching depletion. The known copper reserves are of low grade ore and high prices, or subsidies have been necessary to stimulate production. The rate of consumption in 1948 indicates that the annual copper deficit will be of the order of 500,000 tons.

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Electrical Essay

Which Box Contains the Network?

Two exactly similar boxes of perfectly conducting material contain respectively, one, a resistor of R ohms, and the other the network shown in Figure 1, with $R=\sqrt{L/C}$. The resistor, and the network, are joined to externally accessible terminals as shown in the figure.

By purely electrical measurements at the box terminals, determine which box contains the simple resistor, and which the network. It is assumed that the resistor and the elements of the network show only their indicated lumped characteristic; that is, that under all tests, the stray capacitance and inductance of the resistors are negligible, the stray capacitance and resistance of the inductor are negligible, the stray inductance and resistance of the capacitor are negligible, and that the stray inductance, capacitance, and resistance of all leads are negligible.

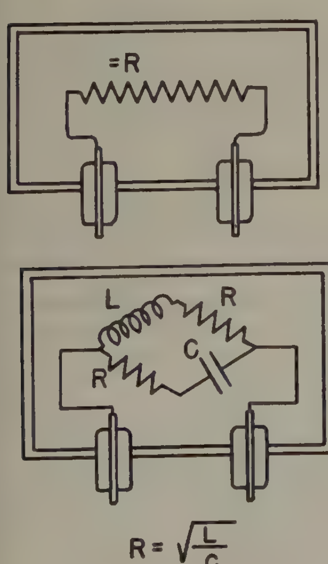

Figure 1

Answer to Previous Essay

The following is the author's answer to his previously published essay (*EE, Nov '48, p 1073*).

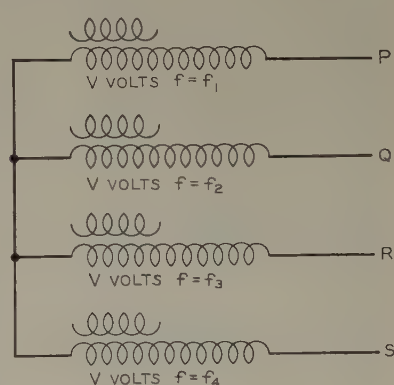

Figure 1

Four of the transformers are connected as in Figure 1, of this answer and are all excited respectively to give V volts in their secondaries but at four different frequencies, f_1, f_2, f_3, f_4. Then the rms voltage from any one terminal to any other will be $\sqrt{2}\ V$ volts. The remaining two transformers may be left unexcited, or connected in any way which will leave the foregoing arrangement essentially unaltered.

Many of the author's friends believed they had found solutions to the electrical problem by using polyphase voltages of a single frequency. However, single-frequency alternating voltages, or more generally, single-frequency sinusoidal functions of a variable t in their combining properties, are isomorphic with (that is, correspond in a one-to-one way to) vectors in a plane, and not to segments (matches) in 3-dimensional space. It is not possible to set down four points in a plane in such a way that the distances between all pairs of the four points are the same.

J. SLEPIAN (F '27)

(Associate director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Silicone Insulation in Submarines—Toxicity

H. P. WALKER T. E. SHEA, JR.

SHIPBOARD electrical installations present special problems for insulating materials that may not exist in shore installations. As naval vessels necessarily are built to a high degree of compartmentation requiring forced ventilation and also have large capacity power plants installed in relatively small spaces, there is perhaps more insulation per cubic foot of available engine room space than exists in land installations. Many naval vessels are complete cities in themselves. An electric fire in a surface ship is extremely dangerous—an electric fire in a submarine is a hazard. For this reason, all electrical-insulating materials used in naval vessels are screened at present carefully to determine their suitability at elevated temperatures and the effects of noxious gases produced on thermal decomposition of these materials. In order to determine the effects of temperature and operation time upon the production of noxious gases from silicone-insulated rotating equipment under condition of simulated submarine service, the Naval Medical Research Institute set out to find the answer to this problem for the Bureau of Ships.

A series of silicone-insulated motors were selected for the actual tests in a 190-cubic-foot pressure chamber with means for controlling the ambient temperature without introducing or withdrawing air during the test, thus closely simulating a submerged submarine. The motors were operated under load in the chamber and actual motor winding temperatures were recorded automatically during the test runs which were up to 96 hours duration. At the beginning of the test and at each 24-hour interval, gas samples were removed from the chamber and analyzed. Also, as the test program proceeded, test animals were placed in the chamber during the runs to determine the effects of the gases on their respiratory system. Finally, two human volunteers were subjected to several test runs of 96 hours duration to correlate the data on test animals to human subjects.

The gases found to be noxious were carbon dioxide, carbon monoxide, formaldehyde, and phenol, with carbon monoxide being the most dangerous gas present in medically significant concentrations. Table I shows test data.

Before the actual test data obtained by the Naval Medical Research Institute could be applied to actual designs of shipboard electric plants, the factors of installed kilowatt capacity and operating times were considered. These data were applied to a fictitious submarine design at right.

From the results of the foregoing tests, it was concluded that properly cured silicone-insulated rotating equipment installed in submarines when operating at observable temperatures not exceeding 230 degrees centigrade continuous temperature did not constitute a health hazard up to 96 hours operating time submerged.

Insulation temperatures of the total installed rotating electrical plan in excess of 300 degrees centigrade, maintained for even short periods of time, constitute a health hazard; however, a single motor "burnout" in a given submarine installation is not believed likely to increase the total level of CO concentration to a dangerous value.

Surface ship installations of silicone-insulated electric equipment, where adequate ventilation and air replacement are maintained, are considered to be safe from the standpoint of CO evolutions regardless of temperature or "burnout" condition.

Table I. Silicone-Insulated Motor Tests

					Rat Values—Determined		Human Values—Calculated	
Motor No.	Rated Amperage (Per Cent)	Motor Temp. (C)	Ambient pCO (mm Hg)	Ambient pO_2 (mm Hg)	COHb Vol (Per Cent)	COHb (Per Cent Sat.)	Alveolar pO_2 (mm Hg)	COHb (Per Cent Sat.)
VA4410	100	48.6	0.00663	130	0.19	0.9	83	1.4
VA4410	125	78.4	0.0223	141	—	—	93	4.0
VA4410	150	111.5	0.0330	157	0.72	3.4	106	5.8
1S3B7284	100	134	0.0433	128	—	—	81	7.2
1S3B7284	125	213	0.0940	136	2.00	9.5	87	15.4
1S3B7284	150	291	0.533	140	6.29	29.9	92	52.2
VA4427	100	62	0.0937	141	1.97	9.4	88	15.3
VA4427	125	89	0.0125	141	0.16	0.8	88	2.5
VA4427	150	119	0.0122	147	0.27	1.3	93	2.3
VA4427	Burn-out	300+	0.604	143	8.40	40.0	90	55.2
UA1957	100	65	0.0110	145	0.19	0.9	92	2.1
UA1957	125	76	0.0139	146	0.21	1.0	93	2.7
UA1957	150	104	0.0147	144	0.37	1.8	92	2.8
UA1957	200	200	0.117	140	3.21	15.3	88	17.5
UA1957	220	270	0.0919	144	2.65	12.6	92	15.0
UA1957	Burn-out	300+	1.700	152	12.55	59.8	99	66.2
UA1957	Burn-out	300+	0.348	150	4.71	22.4	98	34.2
VA4239	100	72.4	0.0140	143	0.21	1.0	90	2.7
VA4239	180	183	0.0471	145	1.17	5.6	92	8.0

Note: Results of exposure of white rats to chamber gas and calculated results for human beings. The figures given represent terminal values for tests of approximately 96 hours duration. Each value for rat COHb is an average from eight animals.

Load in Kw	Operating Time in Hours	Estimated COHb Concentration in Per Cent					Insulation Weight Factor
		150 C	175 C	200 C	225 C	250 C	
500	96	7.0	9.0	11.5	14.5	18	1
1,000	72	8.0	12.0	15	12.0	25	2
2,000	48	8.0	12.0	18	24.0	30	4
2,500	24	2.5	6.0	10	15.0	22.5	5

Notes: 1. COHb values for 500 kw at 96 hours from NMRI test data.

2. For all practical purposes, the weight of insulation for 1,000 kw, 2,000 kw, and 2,500 kw is the same as for 500 kw. However, assuming that double the kilowatt will double the weight of insulation, the COHb values are as shown.

3. Values of COHb at 1,000, 2,000, and 2,500 kw are based on actual 500-kw test readings at 24, 48, and 72 hours multiplied by insulation weight factors.

A digest of paper **48-220**, "Silicone Insulation in Submarines—Toxicity," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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An Electron Tube for Viewing Magnetic Fields

S. G. LUTZ
MEMBER AIEE

S. J. TETENBAUM

Magnetic field patterns may be "seen" through the use of specially-constructed gaseous diodes which produce luminous ionized beams that follow the direction of the flux paths.

THE ELECTRON TUBE to be described is a gaseous diode producing luminous ionized beams which closely follow the direction of a magnetic field and thus give observers the impression of actually seeing magnetic lines of force. The phenomenon of an electronic beam following a curved magnetic field may seem strange, as it is well-known that a moving electron in a magnetic field experiences a force perpendicular to the plane defined by the directions of its motion and of the magnetic field. This phenomenon is employed in magnetrons, in magnetic deflection of cathode-ray beams, and even in the tube to be described. In the more familiar applications the major component of electron velocity is perpendicular to the magnetic field and the diameter of the circular or helical orbit is relatively large. In this magnetic field tube, however, the electrons' perpendicular components of velocity are so low that their orbits are tight helical beams. The rather surprising feature is that the axes of these helical beams bend with the curvature of the magnetic field and follow it quite accurately, as will be shown in the mathematical analysis given on subsequent pages.

DESCRIPTION

A typical electrode structure for a simple magnetic field tube consists of an oxide-coated cathode and a coaxial anode having perforations or slots. Electrons are accelerated toward the anode and some of them pass through the anode holes. The tubes are filled with mercury vapor so the anode potential is limited approximately to the mercury ionization potential, only 10 to 15 volts, and the electrons emerge from the anode perforations with correspondingly low velocity.

The emerging electrons produce ionization of the mercury vapor and the consequent deionization is visible as the characteristic bluish glow in the regions where ionization has occurred. This method of making visible the paths of electrons has been used by Kilgore,[1] Rose,[2] and others for studying electron orbits in magnetrons, image tubes, and so forth.

The major velocity component of the electrons emerging from anode perforations is in the direction of the magnetic field and this component of velocity does not cause a deflecting force except as it gradually deviates from the curving field. Because the total accelerating potential is only 10 to 15 volts, the velocity components perpendicular to the field are very low, probably corresponding to a volt or so, thus explaining the very small diameter of the helical orbits obtained with even moderate magnetic fields. For example,

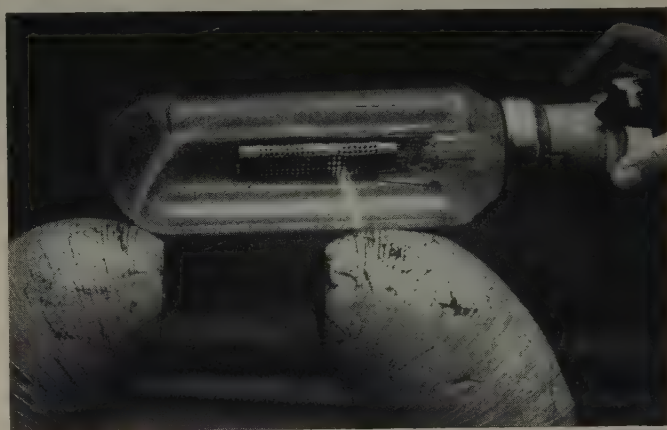

Figure 1. The magnetic field tube operating across a magnet gap

if the perpendicular component of velocity is that of an electron which has fallen through two volts, 8.4×10^5 meters per second, and the magnetic flux density is 100 gausses or 10^{-2} weber per square meter, the diameter of the helical orbit will be slightly less than one millimeter. It must be remembered that electrons emerge throughout the area of each anode perforation so the beam diameter near the anode will be approximately that of the perforation plus twice the diameter of the helical orbits. Of course, there also is considerable focusing action inside of a nonmagnetic anode.

It must be emphasized that these tubes are intended only to show the directions of magnetic fields and not to measure the field strength. The spacing of the beams is determined by the spacing of the anode perforations and not by the "flux lines" per unit area. Some qualitative information concerning the field strength is furnished by the convergence or divergence of the bundle of beams and by the sharpness of focus of the individual beams. At present this tube seems most useful as a demonstration device. However, it may be used to map fields by successive exposures on a single photographic negative, a print of which then may be used as a guide to reduce the labor of conventional flux plotting procedures.

HISTORY OF DEVELOPMENT

It is probable that others have observed this phenomenon of ionization focused into beams following curved magnetic

Essentially full text of a paper presented at the National Electronics Conference, Chicago, Ill., November 4–6, 1948.

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The authors wish to acknowledge appreciation for the facilities and assistance provided by Professor R. H. George of Purdue University, Lafayette, Ind., in the construction of the first tube, and by Myron Youdin and Doctor Alexander Senauke of the Amperex Electronic Corporation, Brooklyn, N. Y., in the construction of the subsequent tubes. Appreciation also is expressed to Robert Watson who assisted with the tests and demonstrations of the first tube while a student at Southern Methodist University, Dallas, Tex.

Figure 3. Magnetic field map obtained by successive exposures (see also the cover of this issue)

fields with an appearance suggestive of the hypothetical magnetic lines of force. However, no mention of the use of this phenomenon in the development of a tube specifically for simulating magnetic flux paths has been found in the literature. The closest approach seems to be Figure 8 of Rose's paper[2] which shows the distinctly helical orbits of relatively high speed electrons in a cylindrical field as a means of illustrating the focusing phenomena in one type of image tube.

This field simulation phenomenon was observed accidentally during an investigation of magnetic control of thyratron discharge in an undergraduate electronics laboratory period being supervised by one of the authors at Southern Methodist University in the spring of 1939. Several students noticed that, when the Westinghouse thyratron was placed in the gap of an electromagnet which was energized after a discharge had been started between the cathode and grid, the discharge penetrated the grid perforations and remained focused in a bundle of tight beams which always bent along the magnetic field as the tube was moved throughout the air gap. A tube exploiting this phenomenon was built the following summer at Purdue University. This tube employed a cylindrical perforated tantalum anode and a coaxial indirectly heated cathode and was sealed in a one-litre pyrex flask. The tube operated successfully and was used for demonstrations several times during the following year but publication of this work was delayed by the war. This first tube was broken during shipment to New York University so the design and construction of other magnetic field tubes was undertaken by the second author as a master's research project.

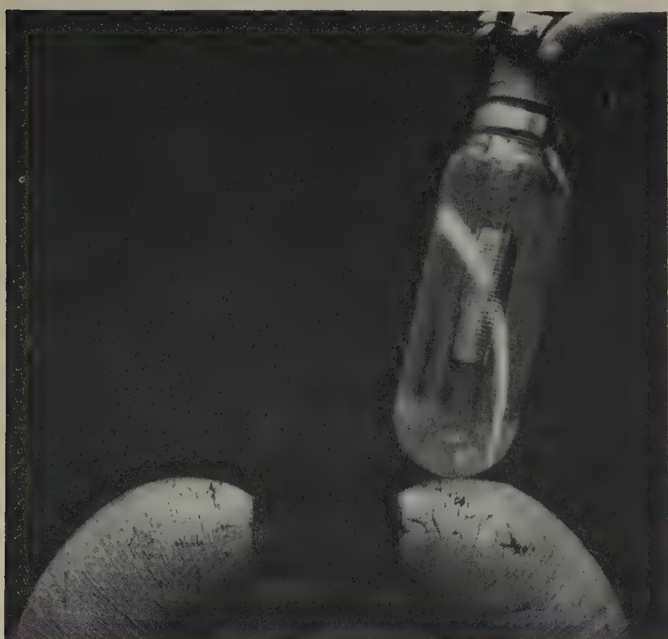

Figure 2. Vertical operation showing convergence of beams in the stronger field close to the magnet

OPERATION

Figures 1 and 2 show the tube being operated in two positions in the vicinity of the air gap of a *720A-E* magnetron magnet whose pole faces and magnetic shunt have been removed. The distinct beams from adjacent anode perforations are observable in Figure 1, while Figure 2 shows the convergence of the bundle of beams as the field intensity increases near the magnet. A plate current of approximately ten milliamperes was used while these photographs were being taken, though operation is satisfactory over a wide plate current range.

Figure 3 shows the use of this tube for mapping the field surrounding the magnet by taking successive photographic exposures with the tube held in different positions. These exposures were made in a darkened room and a final exposure of the magnet alone was made with the lights on and the tube removed.

It will be noticed from these illustrations that beam formation initially occurs inside of the anode over the area occupied by the helical cathode and that this broad beam is broken into a bundle of sharper beams by the anode perforations. A tantalum anode is used to avoid distorting the magnetic field and consequently it provides no magnetic shielding of the internal discharge.

This tube also has been operated in 60-cycle alternating magnetic fields with the only observable difference being slightly less distinct focusing and a slight general glow occurring during the instants of field reversal.

Satisfactory focusing is obtained in flux densities as low as 10^{-2} weber per square meter and the operation of a larger tube would be satisfactory even in weaker fields, as the sharpness of the beams is judged in relation to the tube size. In very intense fields the discharge may not be continuous but may favor one or the other side of the anode unless care is exercised in orienting the tube.

ELECTRON ORBITS IN A CURVED MAGNETIC FIELD

The motion of an electron in a cylindrical, or symmetric-magnetic field alone will be considered since any small section of an irregularly curved field may be approximated by a section of such a cylindrical field. The following approximate equations of motion of an electron in such a field have been given by Rose.

$$r-r_0=r_0\left[\frac{v_z}{\alpha}+\left(\frac{v_\phi}{\alpha}\right)^2\right]\left(1-\cos\frac{\alpha}{r_0}t\right) \tag{1}$$

$$Z=r_0\left[\frac{v_z}{\alpha}+\left(\frac{v_\phi}{\alpha}\right)^2\right]\sin\frac{\alpha}{r_0}t+r_0\frac{v_r}{\alpha}\cos\frac{\alpha}{r_0}t-\frac{v_\phi{}^2}{\alpha}t \tag{2}$$

$$\phi=\frac{v_\phi}{r_0}t \tag{3}$$

In these equations r, ϕ, and z designate the radius, angle, and axial distance in the conventional cylindrical co-

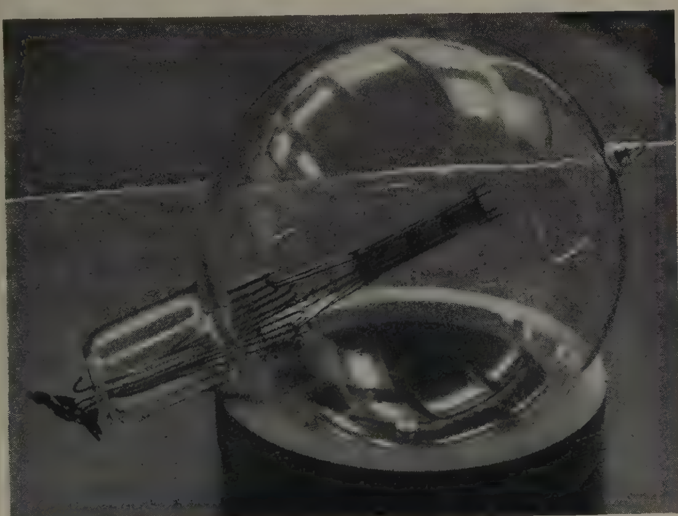

Figure 4. Modified tube with five cathodes

ordinate system. The initial or reference radial distance at which the electron enters the field is designated by r_0. The electron's initial velocities in the co-ordinate directions are designated as v_r, v_ϕ, and v_z. The remaining parameter,

$$\alpha=\frac{e}{m}Hr \tag{4}$$

is a constant since H varies inversely with r in a cylindrical field.

The first two of these equations contains all the information concerning the accuracy with which the electronic orbits follow the field while the third merely tells that the velocity component along the field will be constant. Equation 1 shows that the radial deviation will be only a periodic one, being zero whenever

$$\frac{\alpha}{r_0}t=2\pi n \tag{5}$$

The axial deviation also is periodic except for the $v_\phi{}^2t/\alpha$

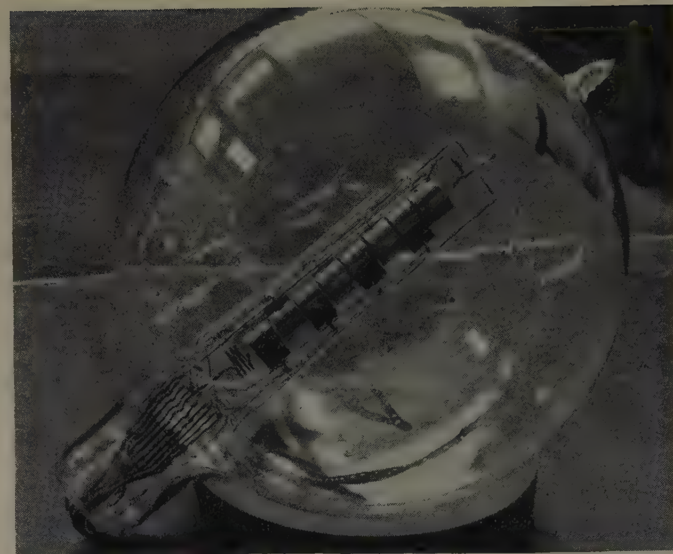

Figure 5. Modified tube with eight anodes separated by beam-forming slots

term which represents a steady axial drift. This term is the only one representing a continually increasing deviation from the true magnetic flux path, as the periodic deviations merely determine the sharpness of focus along the beam.

Fortunately, this axial deviation is much lower in these magnetic field tubes than in the image tubes studied by Rose, as the ϕ velocities which he used were at least ten times as high as when the velocity is limited by the mercury ionization potential. As an illustration of the small magnitude of this axial or shear distortion, assume that the electron's ϕ velocity is 2×10^6 meters per second, or about five per cent higher than that necessary to ionize mercury vapor. If such an electron moves ten centimeters along a field of 100 gausses having a radius of ten centimeters the axial drift will be approximately 0.1 centimeter. Furthermore, the tube normally is viewed from the axial direction as it is moved about the magnetic field so this slight distortion is along the line of sight and there is no distortion in the projection which is seen.

SUGGESTED DESIGN IMPROVEMENTS

The tube used for the accompanying illustrations has several obvious design shortcomings, worst of which is that it employs a concentrated helical cathode and beams therefore emerge from very few anode perforations at one time. However, the use of a long coaxial cathode may not alone be sufficient to obtain strong beams along an entire row of anode perforations. The first tube, built at Purdue University, employed an indirectly heated coaxial cathode but beam formation in a magnetic field was limited to a small portion of its length. This phenomenon seems similar to the inequality in current distribution between mercury vapor rectifiers when they are operated in parallel without current equalizing reactors or resistors and it should be possible to overcome this difficulty by providing a plurality of cathodes or a plurality of anodes with individual current equalizing resistors.

Figure 4 shows one attempt in this direction employing five separate 6H6 cathodes, with the electrode structure

sealed in a 5-litre spherical pyrex chemistry flask. Unfortunately, the cathode activation was defective. Figure 5 shows another electrode structure with eight anode cylinders separated by narrow slots, sealed in a 12-litre flask. Its 2-ampere oxide-coated filament is deflected too severely in a magnetic field and one of the anode connections came unwelded while it was on the pump. Lack of time prevented remedying these defects.

For the benefit of anyone contemplating the construction of one of these tubes it is suggested that the sectionalized anode be used with an indirectly heated coaxial cathode. Extruded ceramic insulators, as used in the early slow-heating cathodes, should be more rugged than the modern sprayed heater insulation. Both ends of the anode structure should be shielded to prevent stray glow. Less leads through the stem will be required if the current equalizing resistors can be incorporated in the electrode structure. Perhaps it may be possible to use a high resistance carbon composition for the anodes. Closely spaced anode perforations, as in the present tube, should be avoided. The anode perforations or slots should be spaced by a half inch or more, depending on the size of the bulb and the length of the electrode structure, so that all the beams will be distinctly separated.

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Career Breadth in Engineering

T. G. LeCLAIR
FELLOW AIEE

The young graduate choosing engineering as a career must select not only a particular engineering field and a specialty within that field, but he also must decide the type of engineering work for which his interests and aptitudes best fit him—be it research, development, planning, design, construction, sales, or production.

ENGINEERING is an expanding field of activity which continually calls for broader backgrounds to cope with new problems. It is also a career which presents opportunities for men with widely different backgrounds and abilities provided that they have the basic requirements for the profession.

The members of the engineering profession can be justly proud that their activities and developments are largely responsible for the quantity production methods which have produced the high standard of living now prevailing in the United States.

For example, from 1919 to 1940, the volume of goods produced per wage-earner almost exactly doubled. At the same time, the average hours worked per week have declined steadily from an average of 50 down to 40. The net result is that in this 21-year period, we accomplished much more than double the output of goods per hour worked. This accomplishment has been brought about by the application of the science of engineering to production processes.

Probably most of those who choose engineering as their career do so because that record appeals to them and they want to be a part of such a group. However, applying rules based on averages to a specific case is always dangerous. Being a member of a successful profession does not of itself guarantee that each individual member of the profession will be a success. The increase in the standard of living has been achieved by closer and more careful application of materials, methods, and forces, but the process has been possible only through increased specialization. Just as we select and use materials and methods so that each is best suited to its purpose, so we must fit human abilities and aptitudes into their proper relationships or we will not attain the highest goal either in performance or in personal satisfaction. This is true because a normal human being is not satisfied, does not feel he is successful, unless he has accomplished the very utmost which he feels was within his ability to accomplish. And he will not be able to do this unless his activities lie within the field where both his interest and his aptitudes are greatest.

Just what is in this package which we know generally as engineering? Whether an engineer chooses electrical, mechanical, civil, agricultural, or chemical engineering as his area, whether he has specialized in illumination, power, or communication and electronics, there are still a number of

Full text of a conference paper recommended by the AIEE education committee and the AIEE committee on Student Branches and presented at the conference on education and Student Branches held during the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948.

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widely divergent fields within each of those areas from which he must select his job.

The engineer stands between the scientist and the tradesman. The scientist is interested in learning new facts regardless of whether or not they may appear useful at the moment. The tradesman uses the tools which have been provided for him in the production of the world's goods and services. The engineer takes the facts which have been learned by the scientist and forms them into new and more efficient tools for the tradesman.

CLASSES OF ENGINEERS

The research engineer is the closest to the scientist. He must have a good basis in pure theory, a competent skill in use of mathematical tools, and an infinite capacity for detail.

The development engineer adapts a particular product to a particular use. He must know enough theory to see the possibilities in the new development, but he must have had enough practical experience to make it work. He must possess considerable resourcefulness and courage to depart from the beaten path if the occasion requires it.

The planning engineer anticipates developments and needs of the future. He must have a clear understanding of the situation and all of its component parts, as well as sound economic judgment. To guess the future, he needs considerable imagination and a recognition of the factors which may arise.

The design engineer produces a product to fit a particular circumstance. He must have a talent for structural visualization, of seeing how things are going to look, and whether or not they will work. He also must have competent working knowledge of construction methods and factory limitations.

The construction engineer must be able to grasp the conception of what is wanted from the plans, he must have an orderly mind and be able to plan ahead so that he can keep the project moving, and he must have ability to handle men without friction.

The sales engineer requires a maximum of personality, a sincere interest in people. He must have a basic knowledge of usual situations and usual practices, but he needs a breadth of vision to recognize special situations requiring special treatment. He must have enough science and mathematics at his command to talk intelligently about technical problems.

The production manager must understand intimately manufacturing processes. He must have a complete knowledge of materials and he also must know how to handle men.

To illustrate this specialized and complex diversity of field and at the same time the oneness of engineering endeavor, let us consider one of the simplest and cheapest products of the electrical industry. This product is an ordinary electric lamp which costs about 15 cents at any electrical, hardware, 10-cent store, or drug store.

Materially, this lamp represents an assembly of perhaps 20 delicate and specialized parts. But, symbolically, it represents the work of two generations of very fine engineers. Thomas A. Edison and a number of associates in 1879 worked many months to make the first electric lamp which gave a feeble glow of light for a few minutes and then went out. This modern product represents about six minutes of a factory worker's time, and can be expected with reasonable certainty to have a life expectancy of at least 1,000 hours.

The engineers behind this lamp are, first, the research engineer who found materials which can be used efficiently without evaporating or oxidizing the filament. The development engineer had to find methods of sealing the current-carrying parts into the glass so that the glass would not break from temperature expansion nor would the vacuum seal be lost. The design engineer produced a simple and sturdy filament support which would be easy to manufacture and assemble. He also selected shapes and types of glass which would be fabricated easily, yet strong enough to withstand breakage from ordinary handling. The sales engineer must acquaint industrial and commercial customers with how to use the device to produce better products, more efficient applications, and more profitable operations. The engineers of the power company have a job all their own to provide the electric current to operate the lamp at a reasonable cost and steady voltage. The management engineer and the production engineer had courage and foresight to provide factories and machines costing many thousands of dollars, but which are capable of producing tremendous numbers of lamps with a minimum of human labor. Development of all these lines has gone hand-in-hand with free exchange of ideas and sharpening of wits necessitated by competition and changing conditions all along the line.

No one of these types of work should be considered better than another. What is important is that each individual must find the spot for which his aptitudes, his abilities, and his interests best fit him. The problem is not easy. It must include a careful self-analysis of the person's own talents and weaknesses, a fair appraisal of his possibilities and limitations and then an intelligent selection of the line of endeavor to which they are to be applied. Some men know the answer before they have entered the profession, some do not learn it for many years.

Universities and colleges do a splendid job in giving the college graduate all of the basic tools necessary to enter the profession. The field of engineering is so broad and so varied that the young men entering the practice of the profession must determine which of those tools he is best able to use for his future advancement. The selection of the right type of work is unquestionably the first step in the development of a good engineer. A man with the assurance that he is doing the work for which he is best fitted will progress the most rapidly and will have the greatest satisfaction in his daily work.

Those in industry, who employ the new graduate, give him good training in his job specialty. At the same time it is the responsibility of each individual, be he a newcomer in the profession or one in practice for many years, to develop a sufficiently broad background to be prepared for broader responsibilities when they arise. By this means, we make better members of the professional team which is doing so much for the growth of the American standard of living.

The Reverse Blowout Effect

GARY J. HIMLER   GEORGE I. COHN
ASSOCIATE AIEE

At high altitudes a d-c arc may move under the influence of an external magnetic field in a direction opposite to that in which it moves at sea level. This graduate student prize-winning article discusses this anomaly, explaining it as a surface phenomenon.

ELECTRICAL discharges generally are classified into two main categories: self-maintaining discharges and non-self-maintaining discharges. The former, such as the electric arc, once it is initiated, does not require any external sources of ionization for its operation, while the latter, such as the spark discharge, can exist only with an external source of ionization. All gases and vapors are in partial ionization at all times because of cosmic rays, local radioactive material, and the sun's ultraviolet rays.

Because pressure of the gas plays an important part in the determination of the characteristics of the discharge, arcs are classified into three groups: high-pressure arcs (above atmospheric pressure), atmospheric arcs, and low-pressure arcs (below one millimeter of mercury). The problem under consideration deals with the atmospheric arc with pressures ranging down to one centimeter of mercury.

STATEMENT OF THE PHENOMENON

A very strange phenomenon has been observed to occur in the behavior of the d-c arc at high altitudes. The cause or effect of this phenomenon never has been explained, and the only mention of it is found in an article by J. S. Quill and L. T. Rader.[1]

Because an electric arc constitutes a current flow, an external magnetic field will exert a force per unit length, $\boldsymbol{F}=\boldsymbol{I}\times\boldsymbol{B}$, on it (see Figure 1). At atmospheric pressure, this force moves the arc in the direction of its application. The velocity of this motion is dependent on the magnitude of the magnetic field, the current in the arc, the length of the arc, and most important of all, the material of the cathode. During the recent war it was observed that at high altitudes an electric arc, under the influence of a magnetic field, moves in just the opposite direction to that dictated by the force, $\boldsymbol{I}\times\boldsymbol{B}$ on the body of the arc.

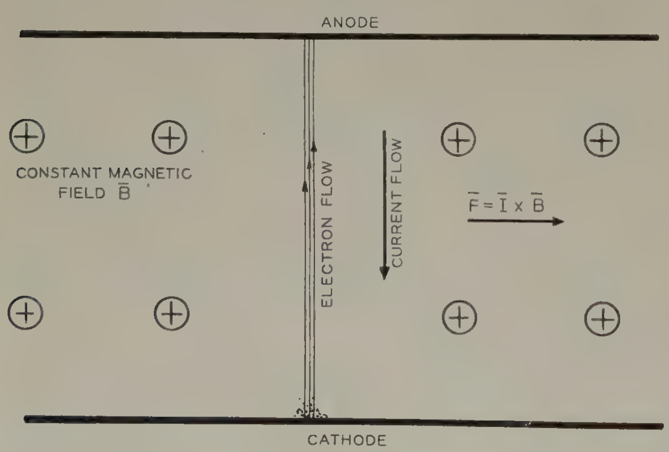

Figure 1. Conditions for the reverse blowout

SOME FUNDAMENTALS OF ELECTRIC ARCS

The greatest obstacle in determining characteristics of the arc discharge is the difficulty of obtaining accurate data about the phenomena occurring inside the arc. This, of course, is caused mainly by the intense heat encountered in the arc, which makes even probe measurements difficult. Thus, there are available only approximate data on gas temperature, electron temperature, current density, and the voltage gradient inside the arc.

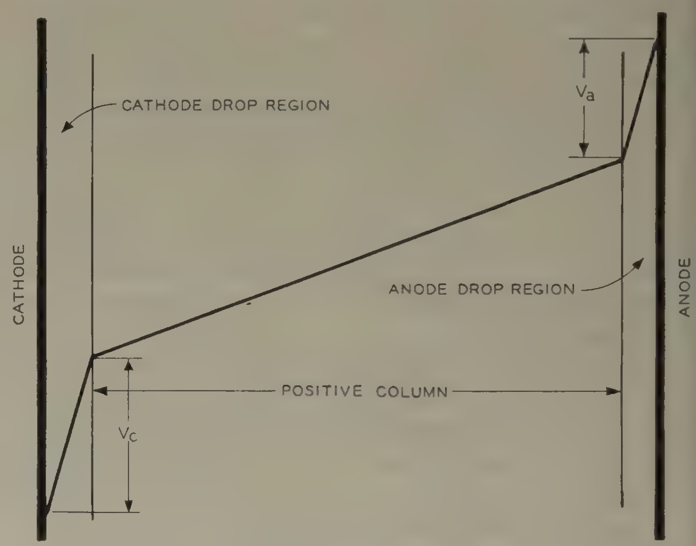

Figure 2. A space diagram of the electric arc

The electric arc is composed of three distinct regions, as shown in Figure 2: the cathode drop region, the positive column or plasma, and the anode drop region. More than 90 per cent of the total arc current consists of electron flow, while the remainder is made up of positive ion movement. The most obvious mechanism for the production of these large electron currents at the arc cathode is thermionic emission. There is present also some secondary emission and some field emission. To achieve thermionic emission, the cathode spot, which is the electron emitter, must be maintained at a very high temperature, ranging from 2,000 to 4,000 degrees Kelvin, depending on the cathode material. This temperature is produced by the energy released by the impact of positive ions on the cathode. These

Essentially full text of a graduate student paper that won first prize at the Great Lakes District meeting, Des Moines, Iowa, April 1–3, 1948. Originally the paper was presented by G. J. Himler, and this is a revised version.

G. J. Himler is electronic engineer, Bell Aircraft Corp., Buffalo, N. Y., and **G. I. Cohn** is instructor of electrical engineering, Illinois Institute of Technology, Chicago.

ions may be produced in the positive column, but it is more commonly believed that they come from the cathode drop region. It can be seen then, that an electron emitted from the cathode must gain sufficient kinetic energy while crossing the cathode drop region, to ionize a gas molecule at its first collision, forming a positive ion, which in turn will bombard the cathode to keep the cycle going. With these considerations in mind, the cathode drop region is assumed to have a thickness of one mean free path of the electron, and a potential difference on the order of the ionizing potential of the gas.

The characteristics of the positive column, or plasma, have been very well summarized by Tonks and Langmuir.[3]

1. At all points in the plasma, the concentration of electrons is approximately equal to that of the positive ions.

2. Electrons within the plasma have the Maxwellian velocity distribution. Their motion can be described as being produced by thermal agitation corresponding to a temperature called electron temperature.

3. The concentration of electrons at any point within the plasma is given by the Boltzmann relation

$n = n_o \epsilon^{V/kT}$

4. The rate of formation of the positive ions corresponds to the concentration of electrons.

5. The thermal agitation of the positive ions corresponds to a temperature almost equal to that of the gas.

6. The actual velocity of the positive ions is determined by the small plasma fields set up by the motion of electrons.

7. Positive ions are formed at the rate of their disappearance at the walls.

The anode accepts the electrons of the positive column and accelerates the positive ions, closing the circuit of the arc discharge. The anode drop has been measured by Langmuir,[2] and was found to be on the order of two to three volts.

DEVELOPMENT OF THE APPARATUS

A suitable apparatus is the most important single factor for the successful reproduction of the described phenomenon. The only data available at the time of the initiation of this work were in the description given by Doctor L. T. Rader[1] in his paper:

To investigate this effect, two devices were used. The first had as electrodes a pair of slightly bowed copper bars mounted to make contact at their centers. They were arranged so that the arc could move horizontally, equally well in either direction. A separately excited source supplied blowout-field excitation. The second device used consisted of a double-break switch with two permanent magnet blowouts and electrodes so arranged that each arc could travel in either of two directions.

The first apparatus used by the author consisted of a pair of brass plates mounted in such a manner that a gap was formed in a horizontal plane. The arc striking mechanism consisted of a piece of carbon which was moved across the gap by a solenoid. This apparatus had to be abandoned after it was found that the edges of the plates pitted much too rapidly under the intense heat created by arc, and thus it was impossible to obtain any accurate quantitative data. The reversal was not observed at that time, but the velocity of the arc did decrease rapidly as the pressure was decreased, and the point of instability was reached. The following measurements were made with this apparatus:

Gap length	5 millimeters
Arc supply voltage	50 volts direct current
Arc current	10 amperes
Pressure	atmospheric
Electrodes	brass

Ampere Turns	Velocity (cm/sec)
60	0.555
120	1.250
180	3.330

The next apparatus consisted of a pair of concentric carbon rings mounted in such a manner as to constitute a horizontal, circular gap, one-quarter of an inch wide. Since the magnetic field was generated by a circular coil around the bell jar, this type of arrangement of electrodes

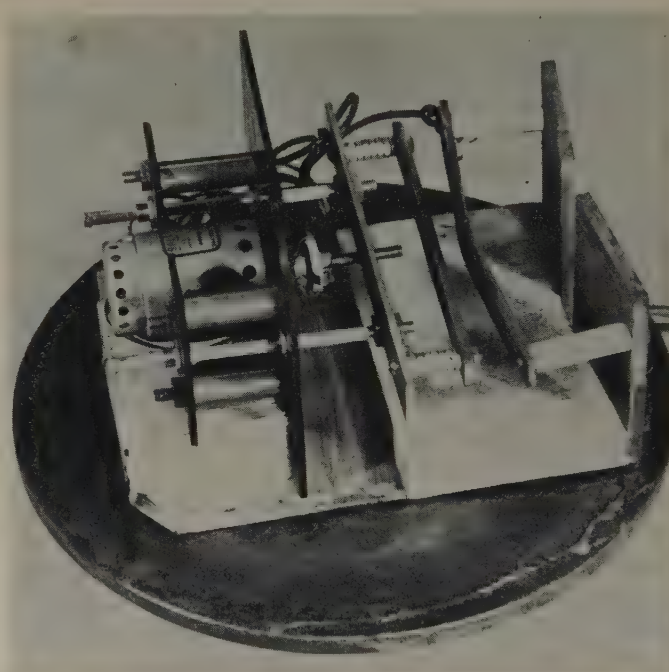

Figure 3. The arc-striking mechanism

would insure a perfectly uniform field over the path of travel of the arc. The following observations were made:

1. If the magnetic field was applied immediately after initiating the arc, the arc traveled along the gap at a very high velocity. It was a very unstable arc and extinguished invariably after traveling at most, one-quarter of the way around the circular path.

2. If the arc was permitted to stabilize before applying the magnetic field, several effects were noted. As the arc stabilized, it formed definite anode and cathode spots, and a weak magnetic field had no effect on the arc. A strong magnetic field caused immediate blowout. Only over a very narrow range of magnetic field strength, 4.05 to 4.55 ampere-turns per meter, a very slow motion of the arc was observed. It was not possible to obtain sufficient data in this narrow region of magnetic field strength to investigate the reverse blowout, and the apparatus had to be abandoned.

The next apparatus consisted of a pair of horizontally-mounted parallel tungsten wires with the same arc striking

mechanism as before. The motion of the arc with these electrodes was found to agree with that observed in the first setup. Again, the critical pressure was reached, but the rapid oxidation of the thin tungsten wires made continuous operation impossible and the apparatus had to be abandoned again.

The final apparatus, with which the actual reversal of the arc was witnessed, is shown in Figures 3 and 4. The heart of the apparatus is shown in Figure 3. Two copper electrodes are mounted in a horizontal position. One is fixed rigidly to the base board, while the other one is attached to a backing plate which can be moved back and forth with the aid of a small motor. This motor is a single-phase capacitor-start motor rated for continuous operation at 115 volts from 400 to 1,400 cycles per second. For this application, the motor was supplied with 115 volts, 60 cyles per second, and the value of the starting capacitor was multiplied by a factor of 20 in order to obtain the rated capacitive reactance. With this arrangement the motor runs at a speed

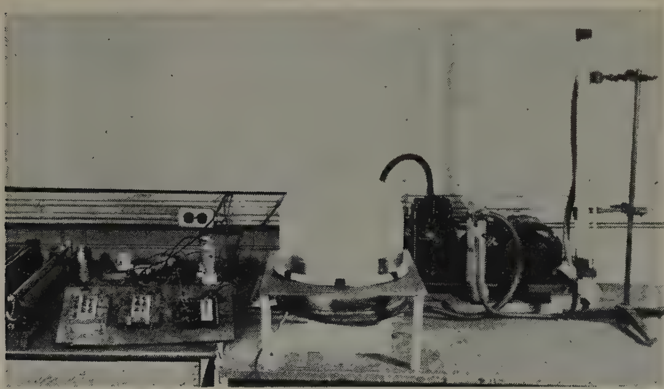

Figure 4. The apparatus setup

of approximately 100 rpm, which is slow enough to allow accurate control of the gap spacing. To start the arc, the movable electrode, which is perfectly straight, is brought in a position to make contact with the apex of the fixed electrode, which is slightly bowed. Then the arc voltage is applied, and the movable electrode is withdrawn. The reversal of the motor, which is necessary to accomplish this operation, is affected by switching the starting capacitor from one winding for the forward direction, to the other winding for the reverse direction. In this manner, the width of the gap can be varied at will.

This apparatus is housed inside a bell jar which can be evacuated to a pressure of less than one centimeter of mercury. The pressure inside the jar can be kept constant to within two millimeters of mercury with the aid of a servomechanism attached to the manometer. This servomechanism consists of a light source which throws a beam of light through the glass tube constituting one leg of the manometer, and a photoelectric cell which is activated by this beam of light. As long as the light is allowed to impinge on the photoelectric cell, the cell conducts and applies cut-off bias to a thyratron. This keeps a relay in the plate circuit of the thyratron inoperative and keeps the vacuum pump idle. As soon as the pressure inside the bell jar rises, the mercury in the manometer leg rises and intercepts the beam from the light source. This de-energized the photoelectric cell, removing the cut-off bias from the thyratron. The thyratron will conduct, energizing the plate relay, which in turn closes the circuit to set the vacuum pump in operation. The pump will operate until the pressure in the bell jar drops to the point where the mercury in the manometer has dropped sufficiently for the beam of light to pass through the glass tube again to actuate the photoelectric cell.

A coil of 60 turns of wire is wound around the bell jar in the plane of the electrodes to supply the external magnetic field. The field distribution inside the bell jar due to this arrangement is discussed in the appendix. The arc voltage is supplied from a 115-volt d-c source, and applied to the electrodes through a bank of dropping resistors which make it possible to vary the arc current. The excitation for the external magnetic field, also called the blowout field, is taken from the same source, and also is applied through dropping resistors.

OBSERVATION OF THE PHENOMENON

Once the arc is initiated, the external magnetic field is applied. Under normal conditions of temperature and pressure, the arc will travel along the electrodes in the direction dictated by the force $\boldsymbol{I}\times\boldsymbol{B}$. As the pressure is lowered, the velocity of travel of the arc decreases rapidly until, at the critical pressure, the arc stops moving altogether.

At that pressure the arc changes in appearance, and is classified as a diffuse discharge. The cross section of the arc decreases greatly, and its brilliance decreases markedly. The anode and cathode spots no longer are well defined, and the arc appears unstable. If the pressure is lowered still further, the arc actually will travel in the opposite direction to that in which it traveled at atmospheric pressure.

Extensive attempts were made to obtain accurate data of this critical pressure. Because of the nature of the problem it was almost impossible to reproduce the experiments with any degree of accuracy, and only qualitative data have been established. This information is shown in Figure 5.

PROPOSED EXPLANATION

The solution of this anomaly seems to be a surface phenomenon. Because the motion of an electric arc depends intimately on the motion of its cathode spot, the surface of the cathode was given the closest attention.

The electrons emitted from the cathode exert a mutual repulsion on each other, thereby causing electrons to move transverse to the arc. This also is supplemented by the fact that the electrons are emitted from the cathode in random direction. At normal temperature and pressure (760 millimeters of mercury and zero degrees centigrade), the concentration of air molecules is so great that the mean free path of an electron is only 9.6×10^{-6} centimeters. With such a short distance, only negligible diffusion of the electrons from the well-defined arc can take place. In particular, the diffusion from the region of the cathode spot is small.

Under the mutual action of the electric and magnetic field, the electrons will tend to travel in a cycloidal path. With the very short mean free path at atmospheric pressure,

the electrons can be considered to travel in straight line segments, as they will follow only the initial portion of the cycloid before undergoing collisions with gas molecules. This is the case for the normal, well-defined arc at atmospheric pressure. However, as the pressure is reduced, the mean free path is increased, and the curvature of the path of the electrons becomes more and more noticeable as they are allowed to travel over larger portions of the cycloid before collision. Thus, the longer the mean free path, the greater will be the deviation of the electrons from straight line motion. At the critical pressure the mean free path has increased to such an extent, that the deviation is affecting the behavior of the arc as shown in Figure 6.

Thus it can be seen, that as the electrons travel greater distances between collisions, the magnetic field exerts a greater effect on them. Considering the extreme cases of transverse motion, one electron can be assumed to travel to the right, another one to travel to the left. The force exerted on them by the magnetic field is $\boldsymbol{F}=q(\boldsymbol{v}\times\boldsymbol{B})$. This force will tend to curve the motion of the electrons in the direction of its application, as explained before (see Figure 6). Those electrons traveling to the right will be forced back into the cathode to the right of where they were emitted, while those traveling to the left will be curved toward the anode. The electrons which are forced back toward the cathode form an electron cloud over part of the cathode spot, reducing further emission from that side of the cathode spot. Electrons traveling to the left, which are the electrons that finally reach the anode and contribute to the actual current flow in the arc, will collide with gas molecules to the left of the cathode spot. Thus positive ions from the gas will be formed to the left of the cathode spot and will bombard the cathode on that side. This will heat up a new region on the cathode to the left of the cathode spot so that emission can take place from the area just to the left of the initial cathode spot. This process causes the cathode spot to migrate to the left. The column of the arc must accompany the spot and thereby is pulled along with it.

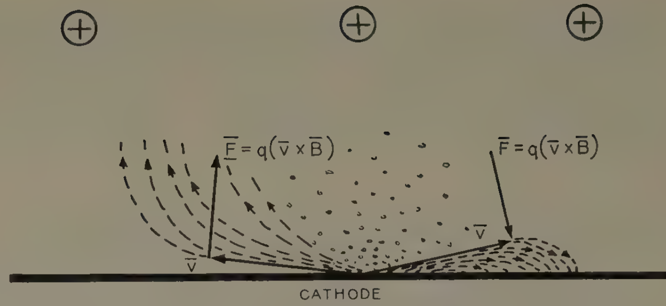

Figure 6. Diagram of the cathode spot at critical pressure

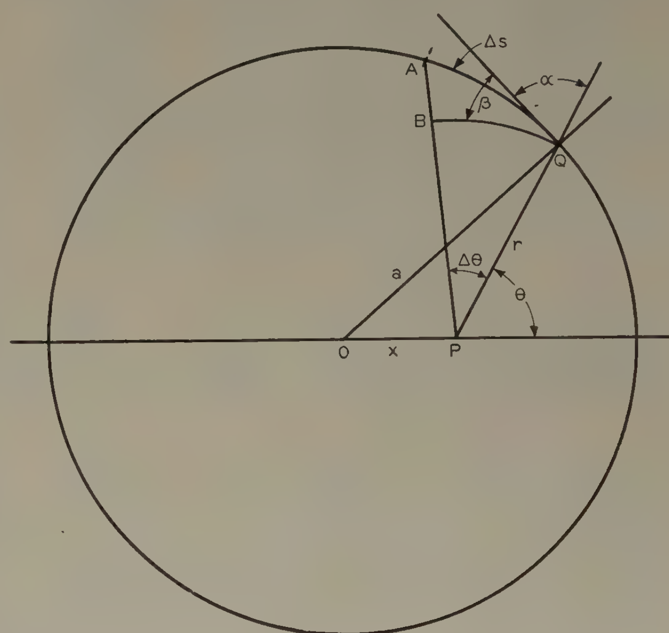

Figure 7. Diagram for the determination of the magnetic field

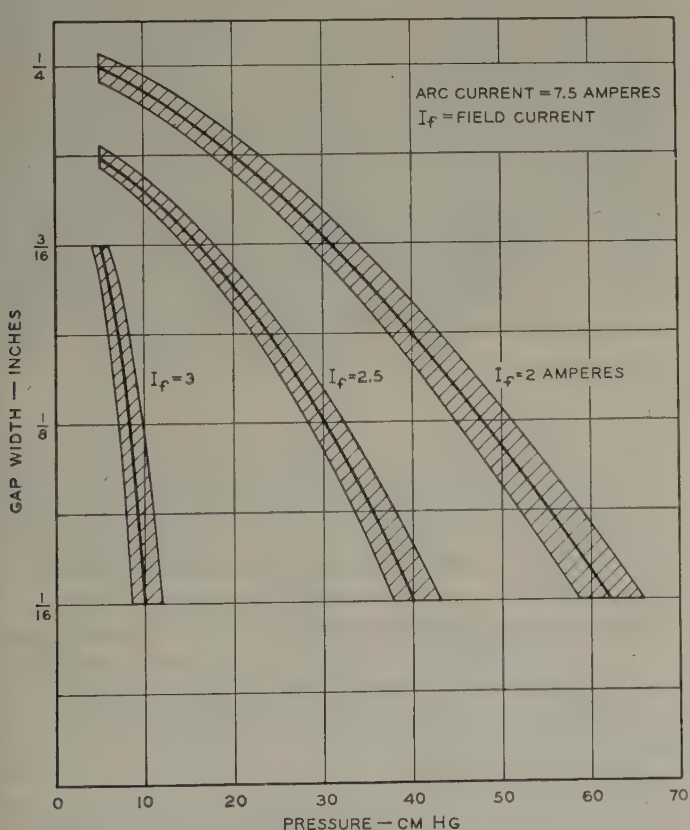

Figure 5. Experimental curves showing the variation in critical pressure with changes in gap width and field current

CONCLUSIONS

Previously cited considerations prompt the following conclusions:

1. The reverse blowout can be interpreted as a surface phenomenon. The force acting on the arc column remains unchanged, while the force acting on the individual electrons increases as the pressure decreases. This force is the cause of the chain of events which lead to the formation of a new cathode spot and make the arc travel in a direction opposite to that dictated by the force $\boldsymbol{I}\times\boldsymbol{B}$.

2. The reverse blowout is a very critical anomaly which can be reproduced only under ideal conditions.

3. The critical pressure is a function of gap width as well as magnetic field strength, which contradicts previously established data.

4. The velocity of travel of the arc is a function of the cathode material and of the condition of the cathode surface, as well as a function of the arc current.

5. The curves in Figure 5 have to be represented as bands as it is impossible to reproduce the points accurately. This is caused by the fact that the observation of the critical pressure is dependent very largely upon the condition of the cathode surface, and the surface changes very rapidly when exposed to the intense heat of the arc.

Appendix. Calculation of the Diametric Distribution of the Magnetic Field

In order to calculate the force exerted on the electrons by the magnetic field, it is necessary to know the field strength inside the bell jar as a function of current flowing in the coil around the bell jar.

Ampere's Law[4] states that

$$dH = \frac{dl \times r}{4\pi r^3} I \text{ or}$$

$$dH = \frac{dl \sin \phi}{4\pi r^2} I$$

From Figure 7 it is seen that $dH = \dfrac{dl \sin \alpha}{4\pi r^2} I$

This expresses the differential magnetic field in ampere-turns per meter in the meter-kilogram-second (MKS) system, where α is the angle between r and dl (multiply by 4π to change to Gauss).

BQ is an arc with center at P and of radius r. Since BQ is perpendicular to PQ the following relationship holds

$$\alpha + \beta = 90°$$

Therefore

$$\sin \alpha . \Delta l = \cos \beta . \Delta l$$

But $\cos \beta . \Delta l = r \Delta l$

Thus $dH_l = \dfrac{I \Delta \phi}{r}$ and

$$H_l = I \int_0^{2\pi} \frac{d\phi}{r}$$

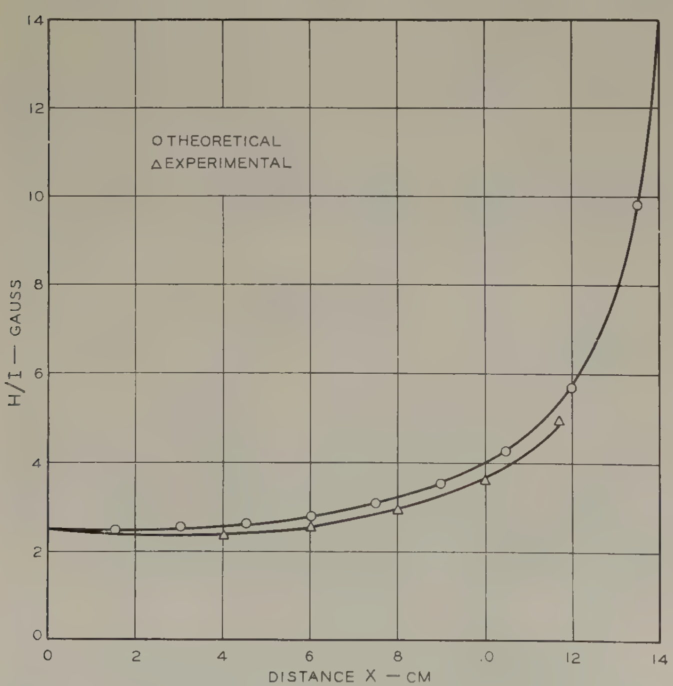

Figure 8. Curves showing the calculated and experimental values of the magnetic field distribution in the bell jar

In the triangle OPQ

$$a^2 = x^2 + r^2 - 2xr \cos (180 - \phi)$$
$$= x^2 + r^2 - 2xr \cos \phi$$

Solving for r:

$$r = -x \cos \phi \pm \sqrt{x^2 \cos^2 \phi + a^2 - x^2} = -x \cos \phi \pm \sqrt{a^2 - x^2 \sin^2 \phi}$$

Since r is a real distance it is positive, and only the positive square root is considered. Thus:

$$H_l = I \int_0^{2\pi} \frac{d\phi}{\sqrt{a^2 - x^2 \sin^2 \phi} - x \cos \phi}$$

Multiplying both numerator and denominator by

$$\sqrt{a^2 - x^2 \sin^2 \phi} + x \cos \phi$$

$$H_l = I \int_0^{2\pi} \frac{\sqrt{a^2 - x^2 \sin^2 \phi} + x \cos \phi}{a^2 - x^2 \sin^2 \phi - x^2 \cos^2 \phi} d\phi$$

$$= \frac{I}{a^2 - x^2} \int_0^{2\pi} \sqrt{a^2 - x^2 \sin^2 \phi} (+ x \cos \phi) d\phi$$

Since $\displaystyle\int_0^{2\pi} \cos \phi d\phi = 0$

$$H_l = \frac{I}{a^2 - x^2} \int_0^{2\pi} \sqrt{a^2 - x^2 \sin^2 \phi}\, d\phi$$

Due to symmetry, this can be written as

$$H_l = \frac{4I}{a^2 - x^2} \int_0^{\pi/2} \sqrt{a^2 - x^2 \sin^2 \phi}\, d\phi$$

$$= \frac{4Ia}{a^2(1-k^2)} \int_0^{\pi/2} \sqrt{1 - k^2 \sin^2 \phi}\, d\phi \quad \text{where } k = x/a.$$

By definition

$$\int_0^{\pi/2} \sqrt{1 - k^2 \sin^2 \phi} d\phi = E(k)$$

and is called the elliptic integral. Then $H_l = \dfrac{4I}{a} \dfrac{E(k)}{1-k^2}$

To generalize this formula for the problem at hand, $a = 15$ centimeters, there are 60 turns in the coil, therefore:

$$H = \frac{(4I)(60)}{(15)(10)} \frac{E(k)}{1-k^2}$$

where I is now expressed in amperes or $H = 1.6I \dfrac{E(k)}{1-k^2}$

The curves in Figure 8 show calculated and experimental values of the field H inside the bell jar and is expressed in Gauss per ampere of current in the coil. Experimental verification of the determined values of field strength in the bell jar was desirable and was obtained by using a flux meter with a pick up coil of 1,000 turns. The experimental results check the calculated values within six per cent.

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Rotating Equipment Ventilation Aboard Ships

A. M. HARRISON
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ONE OF THE MOST important limitations to the capacity of electric machinery is the temperature of the windings. The more efficient the ventilation system can be made, the greater will be the output which can be obtained from a given amount of material, while still maintaining the temperature within proper limits. This is the ultimate aim of the designer and is extremely important on shipboard where space is usually at a premium.

Improved ventilation of machines can be obtained by directing the air so that it is most effective. This can be done by designing baffles and end bells. Blowers frequently are used either as an integral part of the rotor or, as in the case of a slow-speed machine, the blower may be driven separately and external to the machine with suitable ducts for directing the air into and out of the machine.

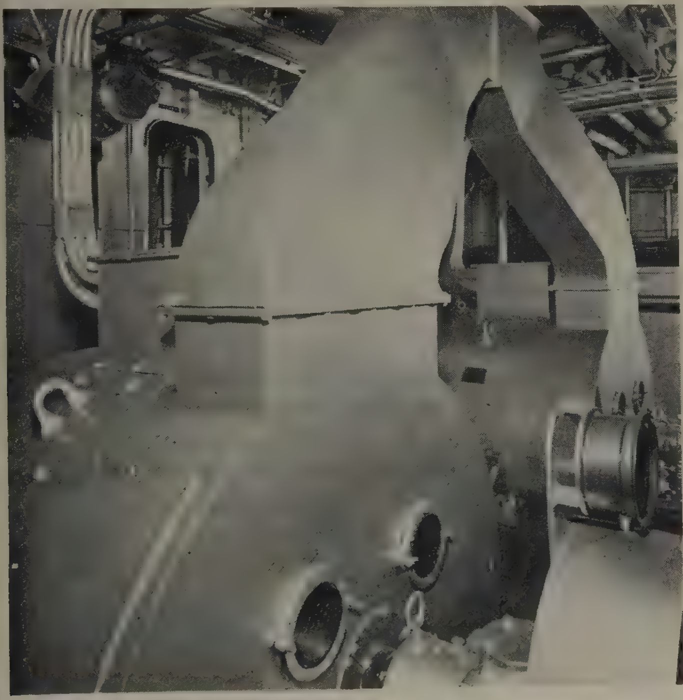

Figure 1. Shipboard installation showing suction-type ventilation

Electric machinery on shipboard practically always is installed in a more or less confined space. This means that forced ventilation is necessary to remove the losses from the machinery space even when it might not be necessary to force ventilate the machine for any other reason. If the hot air were not removed, the ambient temperature would rise to prohibitive values, and even if insulation were used which could stand abnormal temperatures, it would be unsatisfactory from the standpoint of operating personnel. In such cases the so-called induced draft system of ventilation may be used. An actual shipboard installation of this type is shown in Figure 1. Two d-c machines have a common exhaust duct which draws the hot air out of the front end of the machines and discharges it above deck. Another system used in shipboard installations is to enclose totally the machine and use a recirculating air system. A built-in heat exchanger is used in this case to dissipate the losses. Such a system is shown in Figure 2 which shows a cross section of a salient-pole a-c generator, self-cooled with a recirculating air system and built-in cooler.

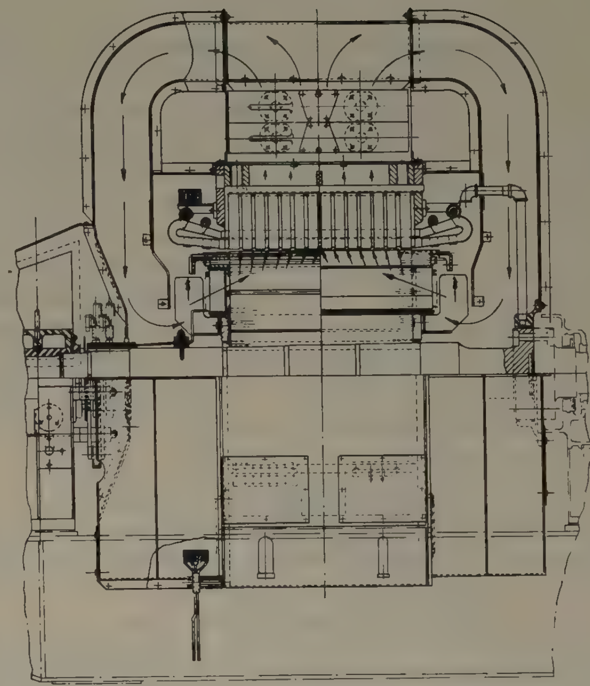

Figure 2. Cross section of a salient pole a-c generator with recirculating air cooling system and built-in cooler

Auxiliary equipment on shipboard often is located in such a manner that serious limitations are imposed on ventilation. Motors must have enclosures varying from dripproof and splashproof to totally enclosed. Totally enclosed motors are used for deck machinery and for locations where atmospheric conditions are unusually bad. In such cases totally-enclosed fan-cooled motors are used.

In conclusion it may be stated that installations of electric equipment on shipboard make it necessary to provide machines with varying degrees of enclosure. The location of the machinery also imposes certain restrictions on the ventilation system. Due to temperature limitations of insulation these machines must be cooled or ventilated, and it is the problem of the designer and application engineer to do this with the most economical use of space and material.

Digest of paper **48-226**, "Ventilation of Rotating Electric Equipment on Shipboard," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Electrical Prerotation of Landing Gear Wheels

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ASSOCIATE AIEE

Landing wheel prerotation often has been considered as a means of reducing tire wear, however a more careful study of the problem brings out other more important advantages, the most important of which is reduction of structural loads. The wheel prerotation described in this article has a number of features to insure reliability. Since adequate electrical prerotation has been achieved, it appears to be well worth consideration for use on very large aircraft with multiple landing wheels.

WHEEL prerotation has long appeared desirable, but only recently with the advent of very large airplanes has it seriously been considered as economically feasible. It has been used on one large airplane, the Lockheed *Constitution*, and has operated satisfactorily. So far, it has been troublefree and, from the limited flight test data available at present, has accomplished its purpose. There are at least three advantages to prerotation:

1. Tire life. No doubt tire life will be improved, but at present no certified data are at hand. It may be that this advantage alone will make some form of prerotation desirable. Even if this factor cannot support prerotation alone, it certainly is a point in its favor.

2. Comfort. It has been established that prerotation makes landings more comfortable. Prerotation landings are so smooth that it is difficult to tell when ground contact has been made unless a landing is rough for reasons other than lack of prerotation. While this item alone probably does not justify much effort toward prerotation, if comfort is obtained in addition to other advantages, it is a favorable additional point.

3. Structural benefit. Structural benefit with corresponding weight reduction may be the greatest advantage to be obtained.

Landing forces may be resolved into two components: vertical loads normal to the ground and horizontal drag loads developed due to the inertia of the landing wheels. Without prerotation, landing wheels must accelerate from zero to landing speed in a fraction of a second. This rapid angular acceleration produces large horizontal forces in the airplane structure. Further, these forces are oscillatory because of the flexibility of the gear and structure and often the reverse loading that results is as high as the forward loading.[1,2] Indications are that this oscillatory action coupled with the high drag loads involved can result in premature failure of the gear as a result of fatigue. The possibility of eliminating or reducing such fatigue conditions warrants serious investigation of prerotation even if its other advantages are not required.

As larger airplanes are designed, with correspondingly larger landing gear, these wheel inertia loads are becoming large enough to warrant a close investigation of the possibility of substantial reduction with prerotation. In one investigation, average drag loads were reduced by prerotation from 41 per cent to 11 per cent of vertical load.[2]

Naturally, these benefits cannot result in a correspondingly large reduction of structural weight because no prerotation equipment available at present can be made 100 per cent reliable, but the possibility of complete failure of prerotation can be reduced considerably by using multiple wheel landing gear with a separate prerotation device for each wheel. If, in addition, the power source for the prerotation mechanism is split to some extent, the failure of part of the prerotation system would reduce prerotation only to the extent of the failure. Thus, as in the case of shock struts used to reduce vertical landing loads, prerotation might be used to reduce horizontal landing loads correspondingly and with equal reliability. This could result in substantial reduction of aircraft structure.

The main landing gear of the Lockheed *Constitution* uses eight wheels, four on each side, all being electrically prerotated. Four nonparalleled generators are used, each supplying two motors. In addition to the motors, vanes are used on each tire as a separate means of obtaining prerotation so that 100 per cent prerotation failure is very unlikely. For this airplane a minimum of 50 per cent drag load reduction was desired, requiring that the landing wheels be prerotated to within 20 per cent of the ideal speed.

WHEEL TORQUE REQUIREMENTS

The constant torque required to maintain a wheel rotat-

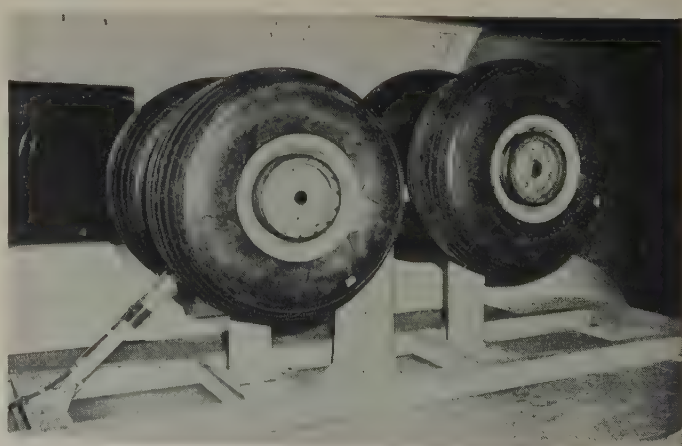

Figure 1. Landing gear assembled in wind tunnel for torque requirement test

Full text of paper 48-230, "Electrical Prerotation of Landing Gear Wheels," recommended by the AIEE air transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

J. H. Keyser, Jr., was formerly a research engineer in the research laboratory, Lockheed Aircraft Corporation, Burbank, Calif.

The author wishes to acknowledge the assistance of **N. C. Clark** and **E. R. Warner**, both of the Lockheed Aircraft Corporation, in the preparation of this article.

ing at various air speeds and wheel speeds was obtained for the Lockheed *Constitution* by placing a full size main landing wheel configuration in the wind tunnel as shown in Figure 1, using the complete set of four wheels. It was found that the shielding effect of the front wheel on the rear wheel was negligible in the case of tires without vanes, but that the torque supplied by vaned tires was considerably less for the rear wheels than the front ones.

The drive used to obtain the data consisted of an integral direct-drive motor. This type of prerotation motor generally is known as the "Dever" motor after the inventor, Otto Dever. The torque was determined by measuring the reaction of the motor stator. The latter was anchored to the axle through a moment arm which acted on an elastic

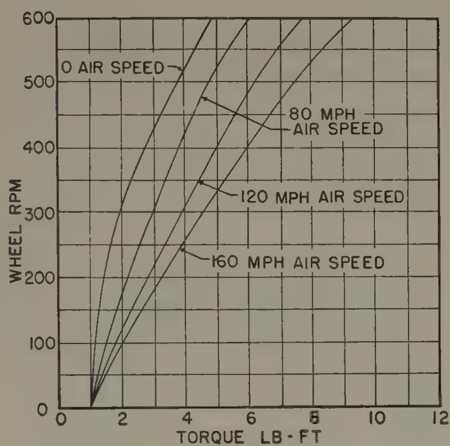

Figure 2. Effect of air speed on the torque required to maintain rotation of an 18 by 20 tire and wheel with no vanes

link to which a resistance wire strain gauge was fastened. The wheel speed was measured through a window in the wind tunnel by means of a "Strobotac."

The curves obtained are shown in Figure 2 for a plain tire and hold equally well for front or rear wheels. Figures 3 and 4 show the characteristics of vaned tires on a front and

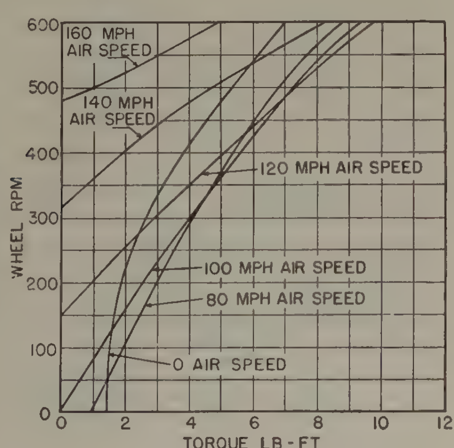

Figure 3. Effect of air speed on the torque required to maintain rotation of an 18 by 20 front tire and wheel with 10-degree vanes

rear wheel respectively. These particular tires had the vanes set at an angle of ten degrees with respect to a radius with the outer ends of the vanes leading. Although the results are consistent within themselves, having been carefully interchecked between runs, the curves may shift along the torque axis on another apparently similar installation

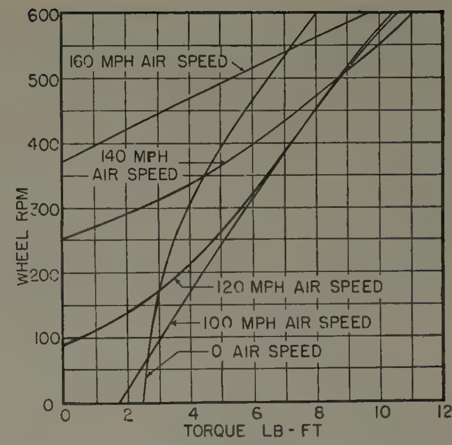

Figure 4. Effect of air speed on the torque required to maintain rotation of an 18 by 20 rear tire and wheel with 10-degree vanes

because of variations in wheel friction, particularly that friction caused by adjustment of the wheel nut. The difficulty of obtaining the same friction conditions, even experimentally, is indicated by the fact that the breakaway torque at zero air speed is different in each of the three sets of data. It is believed, however, that the values obtained represent

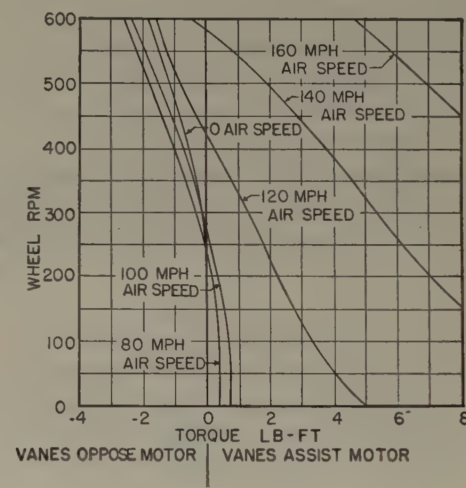

Figure 5. Effect of 10-degree vanes on motor torque required to rotate an 18 by 20 tire and wheel

near minimum torque values, and that all practical values will be the same or greater by not more than five pound feet as this was the maximum increase found in the tests.

The data were obtained with Hayes 18 by 20 inch wheels and Goodrich 18 by 20 tires with a static unloaded diameter of 50 inches. The data should apply fairly well to other tires and wheels of approximately the same size. If, however, the size and shape of the wheels and tires differ greatly from those used, the data cannot be relied upon to be accurate. Mathematical extension of the data to other wheel sizes might be made, but the calculations would involve uncertain assumptions and probably would have to be verified by wind tunnel tests.

EFFECT OF TIRE VANES

Data were obtained for tires with nine vanes per side, and for only one configuration of vanes. An analysis of these data shows that this configuration at least probably should not be relied on to assist the motor in starting. Even at 120 miles per hour air speed, the torque produced by the vanes to assist the motor is so small (actually measured at less than

four pound feet) that a misadjustment of the wheel nut could prevent the wheel from rotating under the influence of the vanes alone. As it is possible that the wheels might be lowered at air speeds less than 120 miles per hour, the vanes cannot be relied upon to assist the motors. Another interesting fact is that at some combinations of wind and tire speeds, tires with vanes require slightly more motor torque to maintain landing speed than tires without vanes. This is shown in the composite curves of Figure 5. If, however, vanes are desirable as an emergency measure to obtain partial prerotation, however slight it might be, in event of motor failure, this extra motor torque might not be considered important.

The speeds that a wheel will attain due to the action of the vanes alone are the cut-off points of the curves at zero torque in Figures 3 and 4. Assuming a landing speed of 85 miles per hour and a tire diameter of 50 inches, full prerotation speed is 570 rpm. Using vanes alone would require speeds that are much higher than landing speed. It is apparent that the vanes used in this test will be very unsatisfactory as a primary means of prerotation for an airplane with a landing speed of less than 100 miles per hour, and will produce only partial prerotation for an airplane with a higher landing speed.

Several other vane angles were compared with the 10-degree vanes by "windmilling" the tires in the air stream and observing the speed attained in each case. There was no significant difference in results, but no general conclusion should be drawn concerning the value of vanes without much more extensive investigation of all phases of the problem.

MOTOR CHARACTERISTICS

The essential difference between a prerotation motor and other motors is the fact that the former must operate for a relatively long time at low speed and high torque because of the high inertia of the landing wheel. Devices to lower the armature current during starting are not desirable due to added weight and complication, so the prerotation motor will draw high currents and thus generate a great deal of heat during the acceleration period. Although starting torque requirements are not excessive, this calls for a motor with high thermal capacity or exceptional cooling ability. It appears that a prerotation motor should not be rated on a horsepower basis since the thermal capacity or cooling and thus the frame size of the motor would have to correspond to a motor of somewhat greater power rating than that of a normal motor having the same starting torque. Therefore, knowledge of starting torque and acceleration time are better measures of the characteristics of a prerotation motor. For the Lockheed *Constitution*, the maximum acceleration time with the wheel starting from standstill was chosen to be two minutes. Any advantage to be gained by accelerating at a faster rate would be permissible provided the weight of the motor was not increased, but it was believed that the acceleration should not take less than two minutes because of safety requirements. The motor should be capable of being run continuously, but there might be a limit on the number of starts it would be required to make in a given time, this time to be short enough to permit a new approach to a landing in the event a first attempt was unsuccessful.

A practical estimate of the required speed torque characteristics of the motor can be obtained by the use of the data shown in Figures 1, 3, and 4. As an example, a plain tire and wheel of 19 slug square feet moment of inertia and 50 inches in diameter were assumed. To be effective, the wheel

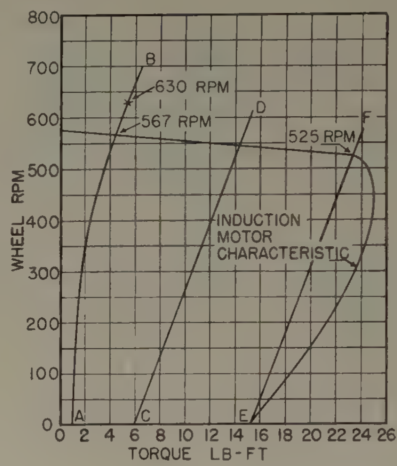

Figure 6. Minimum torque requirements of an a-c induction prerotation motor

must turn within 20 per cent of landing speed. If wheel speed is held between the limits of 525 to 630 rpm, landing speed will be 85×10 miles per hour. Development of the speed torque characteristics for this condition is shown in Figure 6. Line *AB* is the wheel speed-torque curve for no wind, from Figure 2. This line is considered the minimum torque required to maintain rotation of the wheel and will determine conservatively the maximum speed the wheel will attain at any time. This speed is limited to 630 rpm and occurs when the motor voltage is a maximum. It was assumed that the airplane would not lower its gear at over

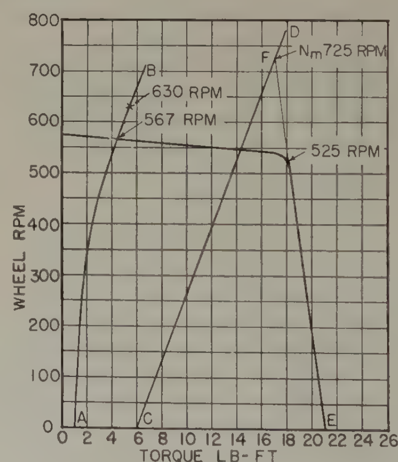

Figure 7. Minimum torque requirements of a d-c prerotation motor

160 miles per hour air speed, therefore the 160 miles per hour air speed curve plus five pound feet to take care of friction variations and wheel adjustment is the maximum torque required to maintain wheel prerotation. This curve is line *CD* in Figure 6. It is now apparent that if the motor is to accelerate the wheel, additional torque to the right of line *CD* must be supplied in order to accelerate the wheel to 525 rpm in two minutes.

Two types of acceleration will be considered. The first is constant acceleration calculated from the equation:

$$T = I\alpha = I\,dw/dt = (2\pi I/60)(dN/dt)$$

If acceleration is constant,

$$T = 2\pi N/60t$$

where

T is torque in pound-feet
I is moment of inertia in slug square feet = 19
N is velocity in rpm = 525
t is time in seconds = 120

$T = (2\pi 19)(525)/(60)(120) = 8.7$ pound-feet at all speeds. Therefore a line *EF* drawn parallel to *CD* 8.7 pound-feet further to the right will be the line along which the motor is required to accelerate. This is the curve for minimum line voltage, normally ten per cent below normal voltage in aircraft practice. Because of this the maximum speed on line *AB* will be ten per cent lower when considered with line *EF*. At 525 rpm the motor should stop accelerating, therefore if a line is drawn through 567 rpm (90 per cent of 630 rpm) on line *AB*, and 525 rpm on line *EF*, the speed torque requirements for a motor operating at ten per cent below normal voltage are specified. At normal voltage, the wheel will accelerate faster, but not overspeed. Ten per cent overvoltage is considered less likely in this application than undervoltage, and if it occurs, wheel speed can be reduced at landing if desired by turning off prerotation a few seconds before landing. Designing for both overvoltage and undervoltage would require the impossible, and absolutely flat speed torque curve.

Figure 8. Dever 120-volt d-c prerotation motor

The similarity of the motor requirements to an induction motor characteristic is outstanding. This makes this analysis useful in designing prerotation motors for airplanes having a-c power.

The second type of acceleration applies to a d-c motor. As the characteristics of a d-c motor will not lend themselves readily to a constant rate of acceleration, a slanting line is picked as the high torque portion of the speed torque curve (Figure 7). The acceleration equation for this kind of curve is

$$N = N_m\left(1 - e^{-(60T_m/2\pi I N_m)t}\right)$$

where N is rpm
N_m is the intersection of line *CD* and the slanting line high torque portion of the speed torque curve

Figure 9. Dever prerotation motor field assembled on the brake flange

T_m is locked torque of motor minus the breakaway torque of the wheel
I is moment of inertia
t is acceleration time in seconds

This equation is derived in the appendix.

Lines *AB* and *CD* are picked as before. If the wheel is to reach 525 rpm in two minutes, an appreciable accelerating torque must be available throughout all this period to preclude a slow exponential approach to this minimum speed. Therefore, the upper end of the slanting line *EF* is assumed to intersect *CD* at 725 rpm in order to give sufficient torque as the motor approaches 525 rpm. Substituting the following values in the acceleration equation:

$I = 19$ slug square feet
$N_m = 725$ rpm
$N = 525$ rpm
$t = 120$ seconds

and solving for T_m, 15.5 pound-feet results which added to the breakaway torque (6 pound-feet) gives 21.5 pound-feet required locked rotor torque.

It can be seen that an increase in T_m with a corresponding decrease in N_m can result in the same acceleration time. Thus the line along which the motor accelerates is not unique.

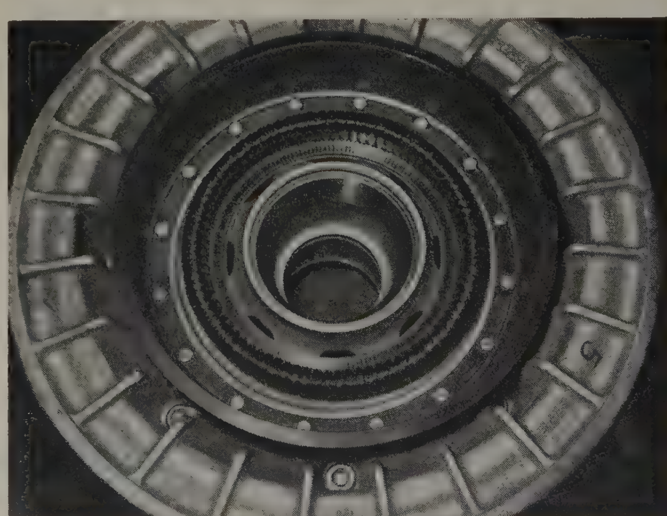

Figure 10. Dever prerotation motor armature in the brake drum

When the motor reaches 525 rpm, the motor characteristic may bend sharply and pass through the 567-rpm point in line *AB* which is maximum speed point for 10 per cent undervoltage. Then, as is the case with the induction motor, at normal voltage the wheel will accelerate faster, but not overspeed.

It is apparent that a d-c prerotation motor must be a shunt or compound wound machine as it is highly unlikely that a series motor could be developed to maintain the full load speed within reasonable limits while the torque required throughout the permissible range speed can vary so widely.

The voltage at the motor during acceleration will be less than the source voltage by the amount of the *IR* drop in the line. In addition, the source voltage may drop under load. The speed torque curves developed in the preceding discussion are developed as the motor voltage varies from a minimum at the start to a maximum approaching the generator voltage at full speed. This effect can be taken into account in the motor design as resistance in series with the motor. This is important as it has been found that a prerotation motor draws a large portion of the generator output during acceleration. In addition, increased armature resistance as the motor heats up during acceleration must be taken into account. This will have the effect of reducing the torque and top speed of the motor.

Having determined the minimum speed torque requirements for a motor, the question arises as to whether a higher locked torque and thus faster acceleration will result in lower motor temperature. This question apparently has no one answer for all cases. A motor designed to give just enough torque to do the job will be the lightest motor, but may overheat unless exceptionally good ventilation is possible. If, however, ventilation is inadequate, a larger motor will have to be used. In the case of a totally enclosed motor, the heat capacity of the motor becomes the major factor in limiting the initial temperature rise. A larger frame, of course, will have a larger heat capacity, but if advantage is taken of the larger frame to increase the flux and hence locked torque, less starting heat will be developed even though the starting current will be higher. This can be shown in any particular case by manipulation of the motor equations and the acceleration equation to give the power loss versus time curve in each case. A comparison of the area under these curves (heat) will show the larger motor with higher starting torque and starting current will generate less starting heat, everything else being equal. Thus if a motor cannot be designed to accelerate the wheel in minimum time without overheating, the motor size must be increased. However, it may be increased less than the amount necessary to give sufficient heat capacity provided advantage also is taken of the higher starting torque, more rapid acceleration, and less starting heat possible with the larger frame size.

"DEVER" PREROTATION MOTOR

The motor developed for the Lockheed *Constitution* is the "Dever" motor shown in Figure 8. This particular model was designed to operate on 120 volts d-c in accordance with Lockheed specifications after an extensive development program by the Lockheed Aircraft Corporation; Otto Dever, inventor; and the Wells Aircraft Parts Company, manufacturer of the motor. The compound wound stator fastens to the brake flange as shown in Figure 9 and the armature attaches to the wheel (Figure 10). The motor is unique only in its shape and in the fact that it revives the ring wound armature. It weighs 13.7 pounds, has an over-all diameter of $11^3/_4$ inches, and is $1^5/_8$ inches thick. The characteristics of the motor at 119 and 108 volts are shown in Figures 11 and 12, respectively. Lines *AB* and *CD* are the minimum and maximum wheel torque required to keep the wheel rotating and are obtained from Figures 3 and 4 as the wheels used on the *Constitution* have 10-degree vanes. Although the motor appears to overspeed at minimum load and 119 volts, armature heating effectively brings the speed down to the specified 630 rpm. At 108 volts and maximum load, the top speed is slightly low, but this is offset to a degree by the tendency of the wheel torque to reduce slightly and thus speed up the wheel as the airplane approaches landing speed. As used, the motor is totally enclosed and has an intermittent rating. Its efficiency is low, but this is to be expected with its ring winding, limited starting inrush, and high torque per pound.

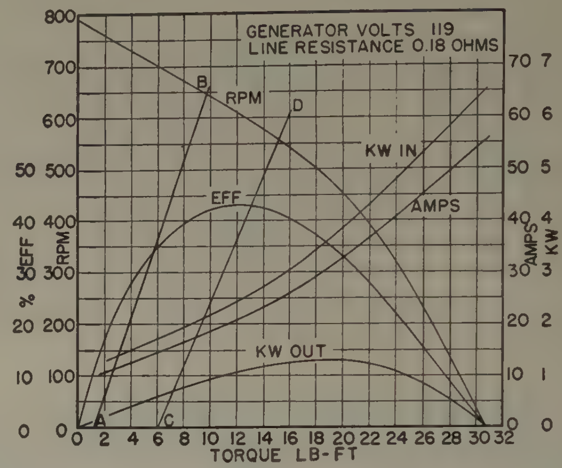

Figure 11. Characteristics of a Dever motor at 119 generator volts

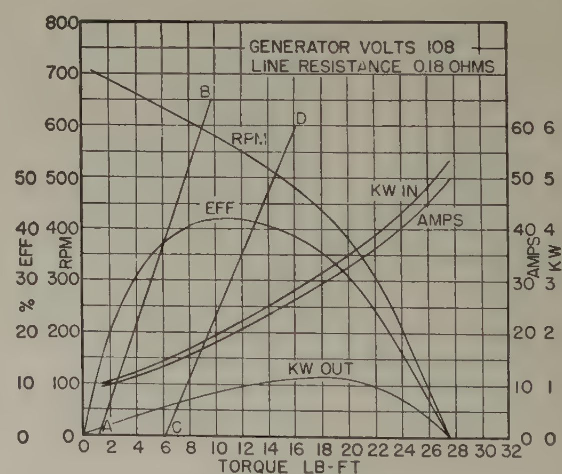

Figure 12. Characteristics of a Dever motor at 108 generator volts

WEIGHT AND POWER REQUIREMENTS

The additional weight required for prerotation has to be balanced against its advantages in an economic design. It is not practical at this time to go into the matter quantitatively and produce an exact answer. The advantages of prerotation have been listed briefly. Against these the disadvantages of additional weight and power must be considered. The weight penalty consists of 110 pounds of motors, associated relays, and wiring. While considerable power is required to turn the wheels, the requirement is not continuous, and in the *Constitution* has been considered as part of the overload requirements of the 120-volt d-c generators. Thus no weight penalty is assumed because of larger generators. It would appear that the advantages of prerotation easily may outweigh its disadvantages, and that over-all weight reduction of aircraft is theoretically possible in the future.

Adequate electrical prerotation can be obtained by the use of special motors designed for a particular airplane. Consideration should be given prerotation early in the design of the airplane so that enough space and ventilation for the motor will be available. If this is done, more efficient and lighter motors can be built with better speed-torque characteristics than those described in this article. Although quantitive performance results are not available at present, practical prerotation has been achieved and appears to have the advantages ascribed to it.

Appendix

Derivation of the acceleration equation for a d-c motor.

$$N = N_m(1 - e^{-(60T_m/2\pi I N_m)t})$$

$$T = I\alpha = Idw/dt = (2\pi I/60)(dN/dt) \qquad (1)$$

α is angular acceleration in radians per second per second
w is angular velocity in radians per second
N is velocity in rpm
I is moment of inertia of the wheel and rotor in slug square feet
t is time in seconds
The equation of a slanting line of the type required is

$$T/T_m + N/N_m = 1$$

Solving for T

$$T = T_m(N_m - N)/N_m \qquad (2)$$

Equating T in equations 1 and 2,

$$(2\pi I/60)(dN/dt) = T_m(N_m - N)/N_m$$

which forms the differential equation

$$\int dN/(N_m - N) = (60T_m/2\pi I N_m)\int dt$$

Integrating

$$\text{Log}_e\,(N_m - N + C) = (60T_m/2\pi I N_m)t$$

or

$$\text{Log}_e\,(N_m - N) - K = (60T_m/2\pi I N_m)t$$

When

$$t = 0,\ N = 0$$

and

$$K = -\log_e N_m$$

Substituting for K

$$-\log_e\,(N_m - N) + \log N_m = (60T_m/2\pi I N_m)$$

or

$$\log_e\,(N_m/(N_m - N)) = (60T_m/2\pi I N_m)t$$
$$N_m/(N_m - N) = e^{(60\ m/2\pi I N_m)t}$$
$$(N_m - N)/N_m = e^{-(60T_m/2\pi I N_m)t}$$
$$1 - (N/N_m) = e^{-(60T_m/2\pi I N_m)t}$$

and

$$N = N_m(1 - e^{-(60T_m/2\pi I N_m)t})$$

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2. Measurements of Landing Gear Forces and Horizontal Tail Loads in Landing Tests of a Large Bomber-Type Airplane, **John R. Westfall.** National Advisory Committee for Aeronautics, Technical Note Number 1140, September 1946.

Wind-Powered Turbine

The problems and advantages of generation of electricity through wind power were discussed in an article by Hermann Honnef in the September 17, 1948, issue of *Electrical Review*, a British publication.

Citing the fact that the annual kinetic energy contained in the airflows of the world corresponds approximately to that being accumulated in the world's entire coal resources, Honnef goes on to the advantages of using wind power in the winter when winds are greatest and the demands for electric power are highest.

To meet this demand, a new high-speed turbine has been constructed experimentally for 5,000 kw with a projected standard capacity of 10,000 kw. It consists of two counter-rotating wheels, the blades of both being interconnected by stiff rings, serving as supports for the field and armature elements of a 3-phase generator. These elements are arranged concentrically so that the inner ring is under pressure, and the outer one is statically under tension. In the air gap between the rings, an electromagnetic field is induced by excitation in the ordinary way, causing the rings to rotate with relatively double velocity.

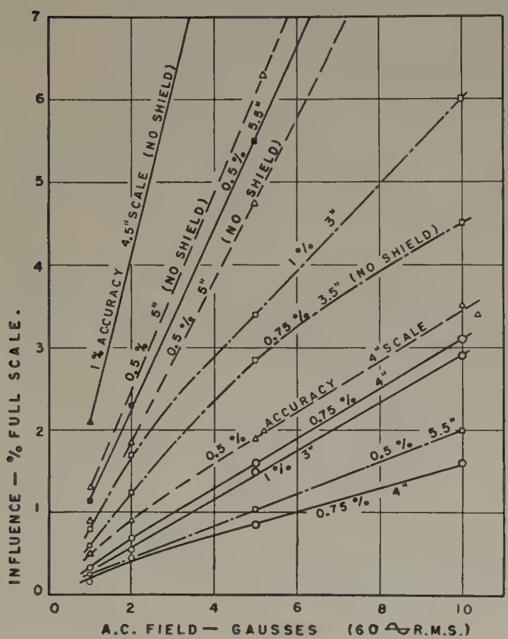
For avoiding overloads and for mechanically regulating the capacity, as well as for reducing shearing effects, the turbine is supported on an antifriction bearing driven wheellike on rails, and rigidly connected to the turbine shaft. With the motion of the bearing, the shaft can rotate from a vertical to an inclined or horizontal position, enabling winds up to 30 miles per hour to be fully utilized, the capacity and shearing moment not increasing within a range of 30 to 60 degrees.

With experimental 20- and 30-kw units, full output has been obtained with the turbine speed braked to two-thirds and using 59 per cent of the wind power with 80 per cent mechanical efficiency. Annual output capacity of the experimental plant is 40 million kilowatt-hours, of which 50 per cent can be stored. Reduction by 10 per cent can be made when feeding directly into a 3-phase system.

Magnetic Influence on Portable Instruments

A. E. PETERSON

THE PERFORMANCE of electric instruments in magnetic fields has been studied as related to portable voltmeters, ammeters, and wattmeters and, a brief survey of certain items of laboratory equipment whose external fields might affect nearby instruments has been made. The influence of magnetic fields on two common types of portable instruments is shown in Figures 1 and 2. The instrument under test was placed in a given magnetic field whose direction was adjusted to produce maximum effect. When a-c fields were used, their phase angles also had to be adjusted. Test instrument readings were held constant by means of a reference instrument so located as to be unaffected by the magnetic field. Readings taken were repeated with the field reversed in direction. Half the difference between the two readings, expressed as a percentage of full-scale deflection, was taken as the influence of the field. Manufacturer's catalogue statement of accuracy, and the approximate length of the scale are shown in the curves to indicate the general instrument quality. It is emphasized that accuracy specified by the manufacturer does not cover such conditions as the presence of magnetic fields.



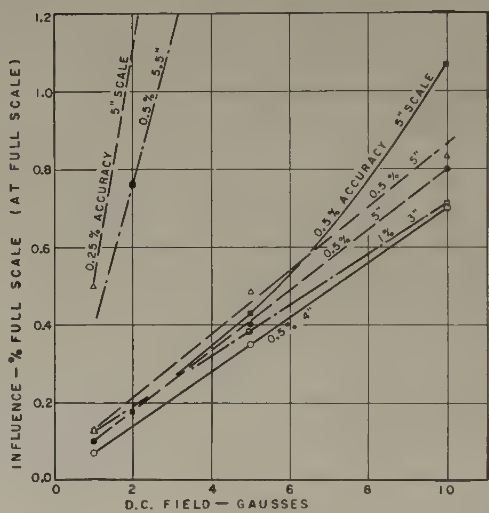


Figure 1 (left). Effect of magnetic fields on moving-iron instruments. Figure 2 (below). Effect of magnetic fields on permanent-magnet moving-coil instruments

Curve values were taken near the upper end of the scale. The influence of a given field was, in general, approximately constant over the entire scale for instruments having a square-law response which include electrodynamic voltmeters and ammeters and moving-iron instruments. (For permanent-magnet moving-coil instruments, having a first-power response the influence of a given field was proportional to the scale reading.) Comparable results for electrodynamic wattmeters cannot be stated so simply since they depend on whether current or voltage is varied. The less consistent results secured with electrodynamic instruments presumably were caused by the influence of shields on internal field distribution and nonuniform scale distribution.

Tests were made on adjustable-ratio autotransformers of 0.5 to 7-kva capacities, voltage-stabilizing transformers of 0.1 to 1-kva capacities, a 1-kva induction regulator, two unshielded instruments, and a number of a-c and d-c generators and motors. Only certain of the first two groups and the larger of the machines (10 horsepower and above) showed fields, close to their cases or frames, of 1 gauss or greater. In all cases the fields decreased rapidly with distance; in nearly all cases, placing an instrument about a half meter away would expose it to a field of less than 1 gauss. Conclusions drawn from all tests show the following results:

1. Permanent-magnet moving-coil instruments which have high-coercivity magnets, or which are well shielded, are usually not influenced by a 5-gauss field to an extent greater than the manufacturer's stated accuracy.

2. Shielded electrodynamic instruments generally were influenced in a 5-gauss field to an extent somewhat greater than their stated accuracies but were within this figure in 2- to 4-gauss fields.

3. All the moving-iron a-c instruments tested showed effects, in 5-gauss fields, greater than their stated accuracies. Most of the shielded ones were within these figures in a 1-gauss field.

4. Of the available laboratory equipment checked, only the larger adjustable-ratio autotransformers, certain voltage-regulating transformers, and the larger rotating machines showed external fields that might affect nearby instruments.

5. Judged by fields found near equipment in the author's laboratory, it is to be expected that fields encountered in ordinary applications of portable instruments generally will be considerably less than 5 gausses.

Digest of paper **48-219**, "Performance of Portable Electric Instruments in Magnetic Fields," recommended by the AIEE instruments and measurements committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

A. E. Peterson is with the National Bureau of Standards, Washington, D. C.

Electric Propulsion for Surface Vessels

N. T. JUCARONE
MEMBER AIEE

DURING RECENT expansion, the United States Navy constructed or acquired more than 1,100 surface vessels powered with electric propulsion. The total capacity installed in these ships exceeded 4,500,000 shaft horsepower, but was limited primarily to vessels with propelling plants of small or medium capacity. Selection of electric propulsion for such vessels was based on:

1. Of those vessels constructed in the decade following World War I, two carriers and five battleships saw considerable service during World War II, showing previous favorable experience.

2. Many electrically propelled passenger and cargo ships, built prior to World War II, have demonstrated the suitability of electric propulsion.

3. Flexibility in the selection of prime movers and in the arrangement of machinery proved particularly important during the recent war because of the necessity of utilizing the most readily procurable types and sizes of Diesel engines and steam turbines.

4. During the recent war the production of large reduction gears became critical and electric drives utilizing slow-speed propulsion motors were employed when ship construction schedules could not otherwise be met.

5. The highly favorable operating flexibility and maneuverability of ships equipped with electric propulsion were of primary importance in such vessels as tugs, ice breakers, salvage and net laying ships.

6. The ability to use propulsion generators for supplying power for large auxiliaries eliminated unduly large ship's service plants in such vessels as tenders, tankers, mine-sweepers, and salvage ships.

The three types of drives employed in naval surface ships are d-c Diesel-electric, a-c Diesel-electric, and a-c turbine-electric. The d-c Diesel-electric drive is employed most frequently in capacities below about 3,000 shaft horsepower per shaft, and in vessels in which optimum operating flexibility and maneuverability are of primary importance. The propulsion motors and generators are usually connected in a closed series loop. Speed control is effected by varying the generator armature voltage, which is accomplished by regulation of generator field current and engine speed. A motor field rheostat is provided so that the propeller speed may be varied independently over a limited range, obtaining rated or optimum output when external conditions influencing propeller load vary, or when one or more of the Diesel-generator sets are taken out of service.

Because of lack of previous naval or commercial experience in the United States, only two naval vessels have been equipped with a-c Diesel-electric drives. Only one of these two vessels, the submarine tender, *USS Sperry*, actually was placed in service. This 10,000-ton ship has two screws, each shaft being supplied by a plant rated 5,900 shaft horsepower. It is the largest commercial or naval ship with this type of drive in the United States. Each plant in the *Sperry* has four Diesel-generator sets and one slow-speed propulsion motor. The motor and generators are salient-pole synchronous machines, with heavy damper windings embedded in the rotor pole faces. Speed is controlled by varying the speed of the Diesel-generator sets. The motor is started as an induction machine and synchronized at one-third rated speed. Dynamic braking is employed during reversals. The generators are paralleled without the use of special synchronizing instruments or equipment.

The performance of the *Sperry* has been highly satisfactory and has demonstrated that in applications where optimum operating flexibility and maneuverability are not of primary importance, the a-c Diesel-electric drive is preferable from the standpoints of weight and space requirements, reliability, and maintenance, to the d-c Diesel-electric drive. As an example, a weight comparison between the a-c electric propulsion equipment in the *Sperry* and corresponding d-c equipment in several tenders having plants of equivalent capacity, revealed that the d-c equipment is 1.5 times as heavy as the a-c equipment.

The a-c turbine-electric drive has been employed in capacities from 2,500 to 10,000 shaft horsepower per shaft in all recent applications, which include destroyer escorts, transports, and oilers.

In this drive, the plant for each shaft consists of one turbine generator set and one slow-speed propulsion motor. The motor is a salient-pole synchronous-induction machine. The generator is a cylindrical-rotor synchronous machine, connected directly to the turbine. Speed control is effected by varying the speed of the turbine-generator set. In twin-screw vessels, the two plants are electrically interconnected so that either generator may be used to supply both propulsion motors at reduced speeds.

Future applications of electric naval propulsion probably will continue as in the recent past, with the exception that engineering and performance rather than procurement considerations will govern, particularly during peacetime construction. However, other marine propulsion developments will offer increasing competition to the use of electric propulsion. Such developments include: reliable, controllable, and reversible pitch propellers, improved types of reversing devices and clutches, and lightweight planetary gears. It is therefore important that further development of electric propulsion equipment be carried on toward obtaining increased reliability and simplicity and reduced weight and size.

Other applications of naval electric propulsion may result because of recent developments and trends, such as the development of gas turbines for marine propulsion, the trend toward higher speed steam turbines, and the increased importance of reducing the noise level of the propelling plant in certain classes of naval vessels.

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Unsolved Problems in the Power Field

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Although the power field has much to offer the electrical engineering graduate, recent years have seen a strong preference on the part of college students for the newer, more "glamourous" fields of electronics and communications. If it is to attract the young engineers it needs, the industry must convince them that there are still challenges to be met in power, that there are developmental problems of just as much interest as those fundamental problems which faced Lamme and Steinmetz, that the power field offers great opportunities in the future.

THE STORY "Acres of Diamonds," was told several thousand times by Russell Conwell. In Conwell's story, an ambitious youth, in search of wealth, started out from Persia to look for diamonds. He visited Africa and all the corners of the earth and finally, as an old man, returned to his home in Persia to die. Shortly after his return, a very excellent diamond mine was opened in his own back yard. He had searched the world over but overlooked his own back yard.

Today, there are many opportunities in the electrical industry, opportunities of varying degrees of stability. Many probably are questioning the old adage, "Opportunity knocks but once." Opportunities are everywhere. In examining them, the young engineer must not permit the glamour of some fields to blind him to the possibilities in the stable and time-tried fields. The past performance of these tried fields is well-known and the future thus is more predictable. The real problem is to be able to recognize the long term opportunities. Some, who have been closely associated with the power field, feel that the brilliancy or glamour of some prospective "diamond field" is causing many to overlook the opportunities in the oldest and best established branch of the electrical industry—the power field. In fact, the colleges generally have noticed a falling off of interest in their students in the low-frequency power field, and in recruiting, employers have found two students interested in electronics and communications for every one interested in power. This article will not be concerned with the reasons why this state of affairs exists, but rather will suggest a selling program to restore the balance. "What does the power field have to offer?" Let us look in our own back yard.

INCREASED USE OF POWER

All industry is expanding rapidly with new plants and factories mushrooming up over night, but power is the key to all. The chemical, steel, paper, petroleum, and coal are a few of the better known industries that have been and still are experiencing growth. The electrical industry is, however, becoming more and more the key to the expansion programs of the United States. Each year more electricity is used per unit of product. Also, the use of labor saving devices is increasing.

Some might feel that these are boom times and that the use of power will rise and fall much the same as the national production. In the recession of 1921, national production fell off 18 per cent from its previous high, while the use of electricity fell off only nine per cent. Furthermore, within one year after 1921, kilowatt-hour consumption reached a new "high," whereas national production did not reach a new peak until 1925. The depression of the early 30's shows a similar cycle. While the gross national production fell 45 per cent below the 1929 peak, use of electricity fell off only 15 per cent. A new peak in use of electric energy was established by 1935 but gross national production did not reach a new high until 1941. Thus, although depressions affect the use of electric energy, so far they have represented mere hesitations in the parade. With the expanded use of electricity in all enterprises in the United States, anyone who has any confidence in the expansion of the country's economy and the improvement in the standard of living also must conclude that the electrical industry is due for continued rapid expansion.

A study recently completed by the market development department of the Westinghouse Electric Corporation of the trends in the use of electricity reveals some rather startling figures. The study was based on information gathered from the best sources and is conservative.

It is anticipated that in 1957 the sale to residential customers will amount to 82 billion kilowatt-hours as compared with 41 billion in 1947; to farm customers 22 billion as against 9 billion in 1947; to small industrial and commercial customers 58 billion as against 38 billion; to large industrial and commercial customers 194 billion as against 113 billion; for miscellaneous uses 18 billion kilowatt-hours as against 16 billion in 1947. This represents a total demand in 1957 of 374 billion kilowatt-hours as against 217 billion in 1947.

In an analysis of the factors contributing to this continued increase in the use of electricity, there are two broad classifications to consider—luxury or convenience power and productive power. In the field of luxury or convenience power, lighting can be considered as an example because it is one of the original electrical loads and it might be considered fully developed. A survey made during the war indicated that there were 100,000 factories, 1,000,000 offices, 1,200,000 stores, 300,000 eating places, and 250,000 gas

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stations all ready to improve their lighting. The introduction of fluorescent lights has given an added impetus to revamping all lighting. This type of light will give twice as many lumens as compared with the tungsten type for a unit of power. In revamping the lighting systems, however, people will not be satisfied with twice the intensity. They will want six to ten times with the resultant increase of three to five times the use of power. While this is classed as convenience power, the humanitarian gains should not be overlooked: less eye strain, better working comfort, and safety. The same is true of street lighting. A marked expansion in street lighting is long overdue. Statistical studies have shown that good street lighting is the cheapest preventive of accidents and crimes.

Domestic load shows a steady growth. Where there was a potential market of 2,500 kilowatt-hours in the home of 1920, there is a potential market of over 10,000 kilowatt-hours in the modern home. New laundry equipment, electric driers, air conditioning and cleaning, cooking and water heating, and the many new types of appliances all contribute to this increase in potential. Also, people have seen how higher light intensities have improved conditions in factories and offices, and will insist on better lighting in their homes. The increased number and use of radios and the introduction of frequency modulation and television all contribute to increased domestic use of electricity. The average domestic consumer now uses 1,400 kilowatt-hours per year. Predictions are that this will double in ten years and some companies believe that when the right time comes, a good selling job will accelerate this growth.

POWER IN INDUSTRY

In the industrial field, the prospects are equally bright. The introduction of high frequencies is opening up literally hundreds of new electric heating opportunities. At the present time, the most common form of high-frequency heating is the induction type. A typical application of induction heating in the 9,600-cycle frequency range is the simple hardening of crankshaft bearings.

There is also use for frequencies ranging from 100 to 450 kc. In this instance, oscillators are used as a source of high-frequency energy, these oscillators being similar to broadcasting station type. The oscillators may range in size from two to 200 kw; as many as 1,200 kw has been used in one installation and applications are being discussed which will utilize as many as 2,000 kw in one installation. Here is an electronic device that is in reality a power device.

The use of still higher frequencies in the megacycle range has developed another field for electricity, known as dielectric heating. The great advantage of this type of heating is that the object is heated uniformly throughout. A 3-inch thick piece of plywood placed in a steam-heated press may require as much as six hours for complete curing, whereas dielectric heating can reduce this time to a matter of minutes. The initial investment per unit and the cost of operation is higher than for steam-heated presses, but the much higher production rate of the press cuts the unit cost of production very materially. There are many other applications for the use of dielectric heating, such as the drying of glues, the curing of rubber, and the preheating of plastics.

The application of electric power to the various industries, of course, goes far beyond the scope of this article. In fact, electricity is becoming the key to practically every industry and every function of modern civilization, and in the discussion of any topic today electricity comes up sooner or later. The best evidence of confidence in the future of electricity is summed up in the statement that within ten years the demand on utility stations will have doubled. Surely this is a challenge to any young man looking for an expanding industry in which to stake his future!

How are these vast amounts of power to be generated? There are many sources of power: solar; wind; sea water; tidal power; hydroelectric power; fuel-burning plants with petroleum, natural gas, or coal as the fuel; and the newest source, atomic energy. None of these can be ignored in thinking of future sources, as their relative importance may change depending on changing economic conditions. As each source has been developed, hand in hand has gone the development of apparatus. There have been many intriguing problems in the development of sources of power and apparatus and these problems are becoming more complicated requiring more and more technical analysis to secure the best solution. Some of the problems in fuel-burning plants make an interesting example of why the power field should be a real challenge to the new generation of engineers.

In the generation of power using the thermal cycle, there has been a continuing increase in steam temperatures and pressures. The highest temperature plant built to date has been for 1,050 degrees Fahrenheit and the highest pressure plant in operation is 2,400 pounds. The increase in temperature and pressure has introduced an infinite number of metallurgical and other problems. The steam generating equipment is the oldest in the power business, yet there are many opportunities for new engineering thinking if more efficient steam plants are to be realized.

The maximum rating of units for steam stations has been increasing continually. This trend has presented many problems, and as improvements are made in the efficiency of plants and as unit size is increased, many more unsolved problems will present themselves. Manufacturers today are building units larger than 100,000 kw at 3,600 rpm and are willing to build 150,000 kw at 3,600 rpm in a single shaft machine. The design of these larger machines has introduced a host of vibration and ventilating problems that have taxed the best brains of the industry to secure a satisfactory solution. These problems have been solved, as proved by the fact that satisfactory machines are in operation. However, as we move forward to use larger machines or machines of improved design in the increased quantities anticipated, there will be increased pressure for more improvements which will require more technically trained men.

The improvement of metals to make possible higher temperatures in the steam cycle at the same time are promoting a new competitor to this steam cycle. The procurement of high-temperature metals will make economical the newly introduced gas turbine. Calculations indicate that where the steam cycle efficiency will be improved from 35 to 38.5 per cent for an increase in metal temperature from 1,000 to 1,500 degrees, the closed cycle gas turbine

efficiency will be improved from 32 to 47 per cent for an equivalent improvement in metal temperatures. There is, therefore, a concerted effort being put into the procurement of higher temperature metals, the attainment of which will make the gas turbine cycle a real competitor to the steam cycle in many fields.

The war dramatized another form of power, nuclear energy. It is still in the research stage and it may be many years before it becomes economically interesting. However, it behooves the power engineer to watch progress and prepare himself to accept responsibility for its commercial use at the appropriate time.

TRANSMISSION OF POWER

But generation is not the only part of the power business that should be attractive to engineers. In the field of transmission, the need for higher voltage is becoming apparent. The installation of power in the amounts mentioned earlier in this article will necessitate higher voltages to distribute the power, otherwise considerable valuable land will be taken up with transmission systems. Also, no doubt some of the more remote hydroelectric projects will be developed as relative costs and availability of different fuels change.

There has been considerable discussion in Europe about the use of higher voltage transmission. The French are considering a grid to knit closely the power industry in France and the adjoining countries. Sweden, which has no coal, is faced with the problem of utilizing the abundant water power in the north in the industrial center of the country in the south, a distance of more than 600 miles. The engineers of France and Sweden are studying voltages up to 400 kv maximum for their projects.

The industry has reason to be proud of its achievements in power transmission. Lightning-proof lines have been built and outages have been reduced to an astoundingly low figure. Enough also is known about switching surges to take these into account in modern designs. In designing any high-voltage system today, the system would be solidly grounded, would be adequately shielded from a lightning point of view, and would have modern circuit breakers so that the line spacing and insulation for voltages above 230 kv would be dictated by switching transients if there were not one further factor in the picture, namely, corona. In considering voltages of the order of 400 kv, the cost increases so with increased voltage that it is necessary to have very close engineering figures on corona loss to allow a closer design than could be made with existing data. It is for this reason that an investigation has been undertaken by the American Gas and Electric Company with the co-operation of their associate companies and a number of manufacturers to secure better data on line design from a corona and radio influence point of view. This investigation is being conducted at the Tidd plant of the Ohio Power Company.

Three lines have been built, two of them 1.4 miles in length and one of one span in length. These are steel tower lines, one of which is equipped with ground wires which can be changed in relative spacing with reference to the phase wires, thus allowing a complete study of the effect of ground wires on corona loss. Different types and sizes of cable are to be studied. Both single conductor and bundle conductors will be strung to arrive at the most economical arrangement. It is anticipated that these tests will run over a sufficient length of time that the corona losses will be recorded during all types of seasonal weather conditions.

The corona tests being conducted are mentioned because they demonstrate to the rising generation of engineers the fact that, even if a lot of good engineering work has been done to perfect the transmission of electric energy, the industry is now on the threshhold of a whole host of new problems. In other words, in this field alone there are a large variety of opportunities requiring just as much resourcefulness and individual attack as the fundamental problems that faced the Lamme's, the Fortescue's, and the Steinmetz's.

Hand in hand with the necessity for higher voltages will go the development of higher voltage transformers, circuit breakers, relaying, and all types of equipment that constitute the transmission system. This means the solution of problems in connection with insulation, circuit interruption, and the problem of building and transporting the large units that will be used with these higher voltages. There are enough problems in this design to fire the imagination of anyone looking for problems to be solved.

The greatest challenge today in the electrical industry is in the design of the distribution system. Concentrations of power in residential areas are being experienced that necessitate increased voltages and our way of life is becoming so closely tied to electricity that reliability is becoming a greater and greater factor. Likewise with the greater use of electric energy in manufacturing plants, particularly in connection with processes that must be carefully controlled, greater care must be used in the distribution of power, not only by the utility but also in the plant itself. If 40 million kilowatts of capacity is installed in the next ten years, more than ten billion dollars will be spent on a distribution system to transmit it from the bulk stations to the utilization point. Here is a branch of the power field where constructive engineering can produce results far beyond those possible in generation or transmission which have been engineered fairly carefully in the past.

The power field has not been mastered with solutions to the problems in generation, transmission, and distribution. With the greater use of electric energy in industry, there is going to be a greater need for men who can design and operate industrial distribution systems and processes. They will have to have a knowledge of mechanical, and other branches, depending on the product, so that they can analyze the processes in the plants and improve them with this increased use of electric power. Many of these processes can be made practical only through technical direction. The industrial engineer will be faced with the problem of not only improving the processes, but also with providing adequate distribution systems to accommodate the end results, taking into account the fact that many nontechnical people daily will come in contact with the utilization device. Likewise, the utilities must have men sufficiently versed in the new manufacturing techniques to sell the use of electricity and make the proper layouts for serving the new types of loads. On the other hand, the manufacturers must have men who not only can sell the equipment to the utility or to the user, but who are capable of tech-

nically analyzing the best performance of their equipment and of suggesting changes better to cope with the broader use of electricity in industry. Back of these people must be men who continually are improving manufacturing processes and the materials used in the product, be it in connection with higher temperature metals, new insulating materials, or a regulator to produce more of a product of better quality.

How are the opportunities which exist in the power field to be sold to college students of electrical engineering, the great majority of whom are interested in electronics and communications? In the author's opinion, newspaper columnists and poorly informed technical writers have oversold electronics. Because of its widespread and admittedly useful applications to Army and Navy communication and control purposes, the idea got around that electronics would solve all future engineering problems. The fact is, as pointed out earlier, that the bulk of the electrical industry for the foreseeable future still will lie in the low-frequency power field, even though many of its control functions will be taken over by high-frequency low-energy devices.

Those who have grown up in the power field, utility engineers, equipment manufacturing engineers, industrial application engineers, must not be backward in talking about the opportunities in that field. The background is one of which to be proud and the future has all the indications of ever-increasing demands for bigger and better equipment.

THE ROLE OF THE COLLEGES

The solution of the coming problems lies with the college students. Industry must work closely with the college faculties. The schools should be asked to concentrate on fundamentals with industry assuming the responsibility of orienting the man and specializing him to the extent necessary. The field of electrical engineering has become too broad to expect the schools to cover it completely in a 4-year course. Four years is not too long to master the fundamentals.

Industry should keep a continuing contact with the professors. This can be done by frequent visits to the colleges, and also by giving the professors the opportunity of summer employment in the manufacturing plants and by providing them with classroom material which they can integrate into their courses as practical examples of the use of fundamentals.

Industry also can help by arranging for inspection trips of junior and senior students through the manufacturing and assembly plants, but most important, industry should have a definite training program for orienting the young man into its ranks. This is one of the best selling points that industry can have.

There is a widely held idea that only the large corporations can afford a training course—but any company, large or small, can set up a course that will fit its particular need and such a course will pay dividends. By bringing young men into the organization at an age when they readily can absorb the functions of the company and make acquaintances among the personnel, they develop an interest and esprit-de-corps which make for happy and permanent employment.

Industry should not stop with the training course. When the young man has been given an assignment, he should be encouraged to continue some form of advanced education. The best young men do not have to be told that education is a journey, not a destination, and they will welcome an opportunity of developing further along lines which will help them with their company.

It is important also that the young man after final placement works under an experienced man who is interested in young men and who will impart to him the challenges in the industry rather than the point of view of the fellow over the hill who simply is working to eke out an existence. In other words, it is important that the young man have the proper perspective and that as he develops, his horizons move farther out so that he will not lose interest. It is inherent in a good man that he seeks work which increases in responsibility as he develops in stature.

The power industry has a bright future but success of the industry depends on the men attracted to it. The difference in men makes the difference between a decadent industry and a progressive industry. Andrew Carnegie once said that you could take away his factories and his money, but if you left him his men he could rise again to a position of leadership. Men are the key to the success of the power industry. Men are attracted by opportunities, and certainly there are many opportunities to be found in this industry today.

European Electric Automobiles

Battery-driven automobiles are being produced in ever-increasing quantities in both France and England. They are being turned out on a large scale in Paris for use as passenger cars in town, and for light delivery service in suburban areas. According to the August 20th and 27th issues of *Electrical Review*, an English publication, the distance covered per charge in these French models averages about 43 miles, a distance which is generally satisfactory for the use of shoppers, doctors, and many business men.

Average speed for this model is about 27 miles per hour, which is the average speed for vehicles within city limits. Quick starting and better braking are numbered among the electrically driven car's advantages and the "suppleness" of the vehicle enables it to be driven more easily in heavy traffic. Four speeds are available without declutching, since a gear box is not used.

Battery charging is through a rectifier, without a transformer, fixed beneath the hood of the car to permit plug connection to any appropriate socket outlet without the driver needing to return to a garage. Cost of recharging the accumulator amounts to a little over $5 a month for runs of about 30 miles daily. The battery can be completely recharged in ten hours, representing a demand of 10 kw at 110 volts.

The British version of the electric automobile is the result of almost ten years of trials by English electrical experts. Though its range is slightly under 40 miles, as compared to the French car's range of 43 miles, it can reach speeds of over 30 mph. To date it has traveled over 25,000 miles.

Multijet Airplane Starter-Generator Controls

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MOST ELECTRIC CONTROL systems and their respective components designed for a multijet airplane are in many respects much the same as those used on reciprocating engine-type airplanes. This is true also with respect to the starter and generator system as used on a recently developed 6-engine jet airplane. One main difference, however, is the starter and generator components themselves. On a standard reciprocating engine-type airplane these two components are separate entities having their own control systems. On this multijet airplane the starting and generating functions are performed by a single unit. This unit is called a "starter-generator" and is rated at 400 amperes, 30 volts direct current, capable of supplying a continuous output of 400 amperes at engine speeds from 4,000–8,000 rpm. The electric system designed to control the starter-generator and its supporting components was patterned, in the early designs, after comparable systems used on standard reciprocating-type airplanes. Modifications, and in some respects complete redesign, of parts of the control system were necessary in order to provide a system which would perform according to the more exacting requirements demanded of it.

The first item that required consideration was the engine starting sequence. On standard airplanes, the starter generally becomes disengaged immediately after the engine has "fired." When starting jet engines, however, it is essential that the starter remain engaged to assist the engine not only to engine firing speeds of approximately 800 rpm, but also until the engine has attained approximately 2,500–2,700 rpm. This requirement led to the use of an automatic starter disengagement system which has been instrumental in reducing the time for starting all six engines. It originally was estimated that the very minimum time for starting six engines would be 15 minutes. However, by utilizing the automatic starter disconnect feature, the pilot has been able to start taxiing within five minutes from the time the first starter was energized. This represents a saving of several hundred pounds of fuel which is a very important item on this type of airplane and very easily could represent the difference between an incomplete and a completed mission.

The second item that was developed for this system was the practice of using common power leads for conducting power to and from the starter-generator. Originally, separate leads were used but after a weight survey was made it was found that the weight of the wire involved was out of proportion to the service the system rendered. It was determined that if a reliable switching arrangement could be designed which would permit the use of common power leads for both starting and generating purposes it would be possible to save a large amount of weight. Several different types of switching arrangements were tried but none were as simple and direct nor reliable as the system presently being used. It was possible to save from 30–40 pounds of weight per engine by utilizing this control system and by multiplying this value by six (for a 6-engine airplane). It can be seen that the total weight saved per airplane represents a large percentage of the total weight of the entire electric system.

Another main item is the incorporation of an automatic equalizer disconnect. On most multiengine-type airplanes the generator equalizer circuit is controlled by a manual generator switch, the equalizer circuit being connected whenever the generator switch is "on." This is proper inasmuch as normally all generators will be operating at an rpm which will insure their connection to the main bus. However, it is a standard procedure on this type of airplane to reduce engine speeds below 4,000 rpm (the lower limit for generator output) on all but two engines during a normal landing. Therefore, to prevent a reduction in bus voltage by failure to de-energize a dead generator's equalizer circuit, the control for each equalizer circuit was transferred to a relay which automatically opens the circuit when its generator is removed from the main bus. Thus maximum possible system stability is maintained with the loss of one or more generators.

Inasmuch as it is standard procedure for this type of airplane to reduce engine speed below 4,000 rpm (the lower limit for generator output) on all but two engines during a normal landing, it is most important that the available system voltage be maintained at its highest level. Therefore, control for each equalizer circuit was transferred from the generator switch to an equalizer cutout relay, controlled by the differential reverse-current relay, to maintain the main bus voltage.

The remaining features of the control system, namely, overvoltage protection and indication, generator cutout due to either throttle cutoff or normal control, starter cutoff, ammeter and voltmeter indication, have been deleted purposely. It was not intended that these features be discussed inasmuch as they are treated in much the same manner as those on reciprocating-type multiengine airplanes. Conclusions show

1. Incorporation of an automatic starter control system has made it possible to reduce the total engine starting time to a very minimum.

2. Utilization of common power leads for both starting and generating purposes has saved 215 pounds of weight per airplane.

3. Provision of an automatic disconnect of the generator's equalizer circuit has permitted maximum possible system stability during the loss of one or more generators.

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The Magnetic Fluid Clutch

JACOB RABINOW

A NEW TYPE of magnetic fluid and several classes of new devices utilizing this fluid have been developed at the National Bureau of Standards. One application of this fluid has been in electromagnetic clutches, but the electromagnetically controlled mixture offers promise for other uses also.

When used in the clutch, operation follows this basic principle: When the space between two parallel magnetic surfaces is filled with finely divided magnetic particles and a magnetic field is established between the two plates, the magnetic particles bind the plates together against movement parallel to their surfaces. The magnetic particles may be finely divided iron which, for most applications, is mixed with a liquid such as oil, to prevent packing and to afford smoother operation of the clutch. When a portion of this mixture is acted on by a magnetic field, the iron particles are mutually attracted, bind together in the field, and the mixture seemingly "solidifies." As the magnetic field can be produced by an electric current, a very simple means thus is obtained for the control of the binding force over a very wide range.

The magnetic fluid most frequently used consists of approximately 90 per cent carbonyl E iron and 10 per cent light machine oil. When this mixture is placed into a magnetic field, the particles of iron adhere quite strongly to each other and to any magnetic surfaces present. For example, when the pole pieces of an electromagnet are immersed in this mixture and a flux of approximately 100 kilolines per square inch is driven through these poles, the shear force between the two poles (assuming that they are relatively movable) is of the order of 20 pounds per square inch of pole area.

The permeability of the mixture is approximately eight and the mixture cannot be saturated under normally impressable magnetomotive forces. The saturation of the solid portions of the magnetic circuit determines the force limits of the devices using this fluid.

With the permeability of the particular mixture known, the magnetic design of a magnetic fluid device follows standard patterns for electromagnetic machinery. In designing clutches the engineer may elect to use a gap of large area or several separate gaps in parallel. This leads to the use of large amounts of iron, but small copper losses. Use of gaps in series requires less iron but more ampere-turns to overcome the resultant high reluctance.

Mixtures are quite thick and the problem of viscous drag when the clutch is de-energized is important. The mixture is also heavy, and centrifugal forces may play a large part in the operation of the devices employing it. For these reasons, high rotational speeds are to be avoided.

To seal the mixture into the clutch in the experimental models, rubber "O" rings have been used successfully. Centrifugal and spiral groove seals also are being tested. Magnetic locks to trap iron particles beyond the seals, and thus keep them out of bearings, appear promising, particularly for the large machines.

Preliminary results indicate that the electromagnetic fluid clutch has numerous advantages over many other existing types. It has extreme smoothness of action because all contacting surfaces, both of the plates and of the iron powder, are coated by a lubricant. The clutch is easy to control and requires very small amounts of electric power. The control is extremely smooth from the minimum, which is determined by the viscous drag of the oil, to the maximum, which is controlled by the magnetic saturation of the iron. Unlike other electromagnetic clutches, which follow a square law wherein the torque is proportional to the square of the current, the torque in the new clutch exhibits the square effect to a markedly less degree, and in some clutches the torque-versus-current curve is almost a straight line below saturation.

Another unusual and desirable feature found in these clutches, particularly when used at low flux densities, is that the value of static friction does not differ measurably from kinetic friction; hence, no discontinuities in torque exist at the instant of initiation of slip. This feature contributes greatly to smooth clutch action, since chattering in an ordinary dry friction clutch is due mainly to the difference between static and kinetic friction.

Because it has no axially moving parts, the clutch is very easy to build, consisting essentially of a driving and a driven member which do not change relative position, except in rotation. In the clutches tested at the bureau, no wear has been noted, but because extensve life tests have not yet been run, it is not possible to rule out wear completely.

In the first experimental model, the driving member was a three-inch disk 0.062 inch thick. The gaps on both sides were also 0.062 inch. The coil was wound in the 3/16-inch space surrounding the driving disk. The magnetic structure of this clutch was made of 47 per cent nickel steel in order to minimize hysteresis effects. In this clutch the value of kinetic friction was always higher than the value of static friction.

This has not been true of all clutches built at the bureau. It appears that at high flux densities, conditions approaching dry friction are encountered, while at lower densities, the lubrication of the iron particles by the oil is more apparent. A larger clutch, six inches in diameter, using five watts of exciting power, can transmit approximately 40 horsepower at 3,000 rpm.

Digest of paper 48-238, "The Magnetic Fluid Clutch," recommended by the AIEE rotating machinery committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67 1948.

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Motor Overload Protectors on Shipboard

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At the present time, the Bureau of Ships uses separately mounted-magnetically or thermally-actuated relays to protect a-c motors from overload, single-phase, and locked rotor conditions. With the advent of silicone-insulated motors requiring different overload relay characteristics, the development of relays operating on the actual motor winding temperature was undertaken.

In setting up the development program for a thermostatic protector, the following operational requirements which the protector would be required to meet were specified. These values were based on the characteristics of available motors, the fact that a silicone-insulated motor can operate continuously at 200 degrees centigrade and can operate for a short time at temperatures up to 350 degrees centigrade.

1. With the rotor stalled before the voltage is applied, the protector shall trip before the temperature of the motor windings reaches 350 degrees centigrade when measured by the rise in resistance method.

2. With the rotor stalled by an overload after the temperature of the motor windings has reached a steady state condition of 200 degrees centigrade, the protector shall trip before the temperature of the motor windings reaches 350 degrees centigrade when measured by the rise in resistance method.

3. With a 25 per cent overload applied after the temperature of the motor windings has reached a steady state condition of 200 degrees centigrade, the protector shall trip within 15 minutes after the motor windings reach a temperature of 210 degrees centigrade measured by the rise in resistance method.

4. With a 50 per cent overload applied after the temperature of the motor windings has reached a steady state condition of 200 degrees centigrade, the protector shall trip within six minutes after the motor windings reach a temperature of 210 degrees centigrade when measured by the rise in resistance method.

5. With an 80 per cent overload applied after the temperature of the motor windings has reached a steady state condition of 200 degrees centigrade, the protector shall trip within two minutes after the motor windings reach a temperature of 210 degrees centigrade measured by the rise in resistance method.

6. The protectors otherwise were required to meet the specification requirements for conventional overload relays.

Three manufacturers have submitted samples which have met the operational requirements specified by the bureau. These manufacturers are Radio Frequency Laboratories, Incorporated, White Rodgers Electric Company, and Spencer Thermostat Company.

The thermostatic protector developed by Radio Frequency Laboratories consists essentially of an invar rod inside of a steel tube inserted in one of the motor stator slots. The difference in the rate of thermal expansion of the invar and steel supplies the force necessary to trip contacts to shut off the motor if overload occurs.

The thermostatic protector developed by the White Rodgers Electric Company consists of a bulb filled with a liquid which expands on increase of temperature. This bulb is wound around the stator end turns and is connected by means of a capillary tube to a diaphragm. On increase of temperature, the diaphragm moves to open a contact in the motor control, thereby stopping the motor.

The thermostatic protector developed by the Spencer Thermostat Company consists of a cup-shaped bimetallic disk attached to contacts. The disk is placed near the motor windings and is heated both by ambient temperature and by a heater which carries the motor current. When the disk temperature reaches a predetermined value, the disk snaps inside out to open the contacts and stop the motor.

The protector developed by Radio Frequency Laboratories has the advantage of being imbedded in the motor slot so that it closely will follow the motor heating curve. However, this protector requires a larger or deeper slot due to the extra space required and cannot be applied to very small motors since a definite movement of the tube is required to operate the contacts. The thermal expansion of the steel rod, therefore, fixes the tube length for a given temperature rise.

The protector developed by the White Rodgers Electric Company has the advantage of ease of installation. However, it has the disadvantage of having some time lag between the actual motor temperature and the temperature of the protector.

The protector developed by Spencer Thermostat Company has the advantage of having very fast action at high values of overload or on locked rotor conditions. However, this protector has the disadvantage of partially depending on motor current for protection.

The chief disadvantages in the use of thermostatic protectors are the extra wiring required at the motor, the space required to mount the protector in the motor, and longer reset time after tripping.

The chief advantage in the use of protectors is that more adequate protection is obtained against overheating from any cause. Furthermore, a smaller number of devices can be used, thereby cutting down on the procurement and stocking problem.

Applying thermostatic protectors to Class A insulated motors presents added problems since the smaller operating temperature range requires more sensitivity and speed of response However, adequate protection can be obtained by using designs as indicated above.

If actual service tests aboard ships prove the protector to be satisfactory, it is expected that such devices will be specified for silicone-insulated motors on future ship designs.

Digest of paper **48-245**, "Overload Protection of Silicone-Insulated Motors for Shipboard Use," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Scandinavia

As Seen by a Canadian Hydroelectric Engineer

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Because neither Norway nor Sweden is very generously endowed with coal or oil resources, the power economy of both countries is founded almost entirely on the utilization of water power which, fortunately, is plentiful. This article on the development of hydroelectric power in Scandinavia is based on observations made by the author, a Canadian engineer, during a visit in the summer and fall of 1947.

A GENERAL REVIEW of the power situation in Scandinavia reveals that Norway has no coal deposits except in Spitzbergen, and although Sweden possesses some coal in Skåne in the southernmost part, it is low-grade ore and normally is used by adjacent industries and railways. In addition, neither country possesses oil resources, beyond oil shales in Sweden, though a large plant was constructed early in the war at Kvarntorp, which has produced fairly large quantities of fuel oil, motor kerosene, and gasoline, as well as light oil. Four different methods are used in this plant: retort ovens of two types, channel ovens, and electric heating of the rock in situ by the Ljungström system.

Both Norway and Sweden do possess substantial forests, however, which are very well managed and, are run to provide a perpetual yield reasonably equivalent, in peacetime, to the annual increment of growth. These forests are the solid foundation on which the wood-products industries, such as pulp and newsprint, are maintained.

Prior to World War II, Norway consumed about 3,300,000 tons of coal and coke annually, together with some 600,000 tons coal-equivalent in wood and 200,000 tons coal-equivalent in peat. Of the coal, approximately 300,000 tons were mined in Spitzbergen, 70 per cent was imported from Great Britain, and the remainder from Germany and Poland. During the occupation, only half the required coal could be secured from Germany so that the usage of wood and peat was increased to make up the deficit.

In the period 1936–39, Sweden imported an average of 8,200,000 tons of coal annually, about half from Great Britain, and the remainder from Poland, Germany, and Holland. During the war, however, supplies from Germany and German-occupied Poland and Holland fell to about 50 per cent of prewar coal and 60 per cent of prewar coke. Consequently, the use of low-grade domestic coal was increased from 430,000 to 600,000 tons; peat some 4,000 per cent; and wood fuel about 467 per cent. Also production of various substitute liquid and gaseous fuels was boosted.

It well can be appreciated that Scandinavia has welcomed the resumption of coal exports from the United Kingdom, balanced by return cargoes of pit props, pulp, newsprint, and other forest products—a logical flow of trade.

Fortunately, both Norway and Sweden have been generously endowed with water power resources. It has been estimated Norway has 9,200,000 kw in economically-utilizable water power, on the basis of power available through-

Essentially full text of an address presented before the AIEE Montreal Section, April 21, 1948.

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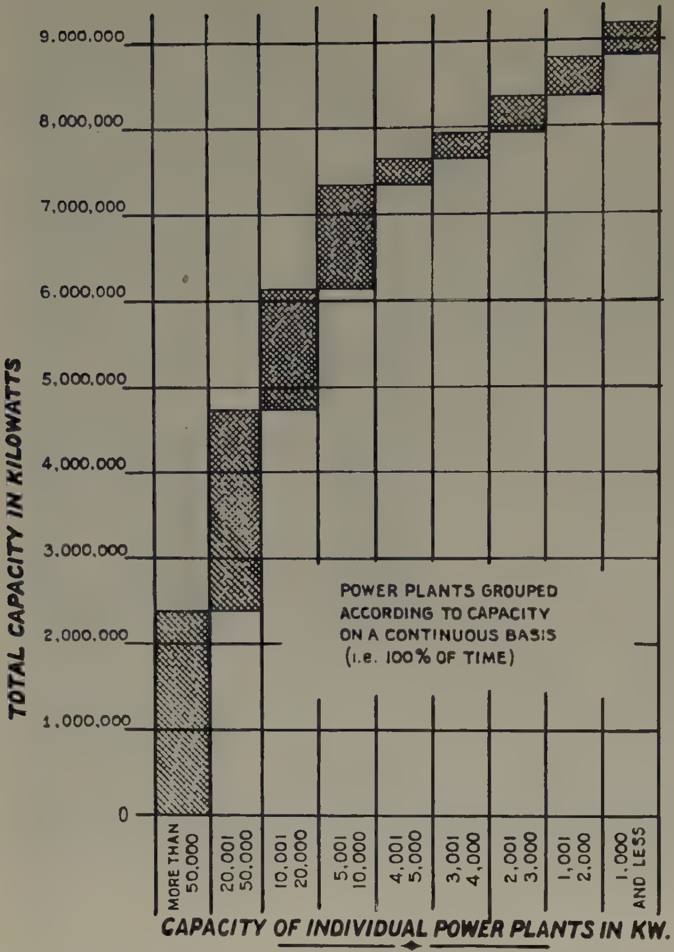


Figure 1. Available hydroelectric power in Norway

out the entire year, equivalent to 80 billion kilowatt-hours per year, while Sweden is estimated to have total water power resources equivalent to 150 billion kilowatt-hours annually, of which 40 billion can be economically realized. Consequently, the power economy of both countries is founded almost entirely on the utilization of water power.

The makeup of Norwegian water power resources is illustrated by Figure 1 while Figure 2 shows the extent of actual development. During 1946 the total generation in Norway was 11,612 million kilowatt-hours; of this all but 30 million was produced in hydroelectric plants, and about 30 per cent of the output from water power stations was generated in plants of capacities under 1,000 kw. Norway's population of just over 3,000,000 thus would set the per capita generation of hydroelectric plants at about 3,865 kilowatt-hours.

In 1946, the installed capacity of Swedish hydroelectric plants was 2,600,000 kw. Total generation in the same year was 14,206 million kilowatt-hours, of which 13,533 million kilowatt-hours was produced by water power, and 673 million kilowatt-hours by steam. This generation equals 2,100 kilowatt-hours per capita for Sweden's population of 6,800,000.

Figure 3 shows how the generation of electric energy in Sweden has developed since 1913. Annual increase in consumption has been about 6.5 per cent of the usage in the previous year.

Today about 80 per cent of the population of Norway is served by electricity for light, cooking, and other domestic uses, as well as considerable house heating and small industry. The remainder of the population lives in thinly-populated areas or in districts difficult to serve at reasonable cost. As a result, the State has undertaken to subsidize the supply of electricity to the more remote districts; from 1938 to 1946 about $4,400,000 was spent on facilities which are expected to total $10,000,000. These installations apparently supply 80,000 inhabitants formerly without service and about 60,000 who formerly had only a partial supply. In 1946, an additional $2,600,000 in subsidies was voted on service facilities estimated at $7,000,000, expected to provide electricity for some 57,000 people.

In Sweden, electric service is available to all in the towns and more densely populated districts. About 85 per cent of rural homes are electrified, and the number is increasing steadily, so that only the most remote are without service.

It will be of interest to look briefly at the breakdown of energy production in Norway, shown by Figure 2. Corresponding data for Sweden indicate 1946 energy consumption as follows:

	Per Cent
Large industry	39.0
Domestic and commercial service	18.1
Electrochemical and electrothermal	13.7
Electric boilers	5.2
Electric transportation	8.3
Export	0.9
Station use and losses	14.8

In Norway, the total installed capacity of electric steam generators is 530,000 kw; of which some 400,000 kw capacity is served by the interconnected power network in eastern Norway and around Oslo fiord. Electric boilers in Sweden absorbed 744 million kilowatt-hours in 1946, or about 5.2 per cent of total energy consumption.

Both Norway and Sweden have large hydroelectric construction programs under way. About 317,000 kw capacity was completed in Norway during 1945–47, most of which was under construction during the occupation. It is expected that about 415,000 kw will be added during 1948–49, about 65 per cent of which was put in hand during the war, and that an additional 700,000 kw will be completed by 1956. As a matter of fact, in 1946 the State's Electrification Board examined the need for additional hydroelectric capacity and recommended an annual increase over the next ten years of 150,000 kw. This is beyond the capacity of the domestic manufacturing facilities for heavy equipment, although they are very good so far as water wheels are concerned.

One of the difficulties faced in Norway, in addition to the planned large-scale expansion of hydroelectric plant, is the repair of damage inflicted by the German occupation forces when they evacuated northern Norway towards the end of 1944. Most of the power stations, dams, and transmission lines in great areas of Finnmark and Northern Troms were destroyed to a great extent, but, although the Glomfjord, Vemork, Naudal, and Oltesvik power plants were damaged, the interruptions to service were comparatively brief.

Quite a number of new hydroelectric developments are under construction in Sweden, both by private interests and by the State, including the 70,000-kw Forsmo plant on the Ångerman River, the 120,000-kw Hölleforsen station on the Indals River, the 260,000-kw Harsprånget power plant on the Lule River, and the 165,000-kw Hjälta station on the Fax River. All told, it is expected total hydroelectric power capacity in Sweden will be increased 38.5 per cent by the end of 1951, reaching 3,600,000 kw, with further substantial expansion planned.

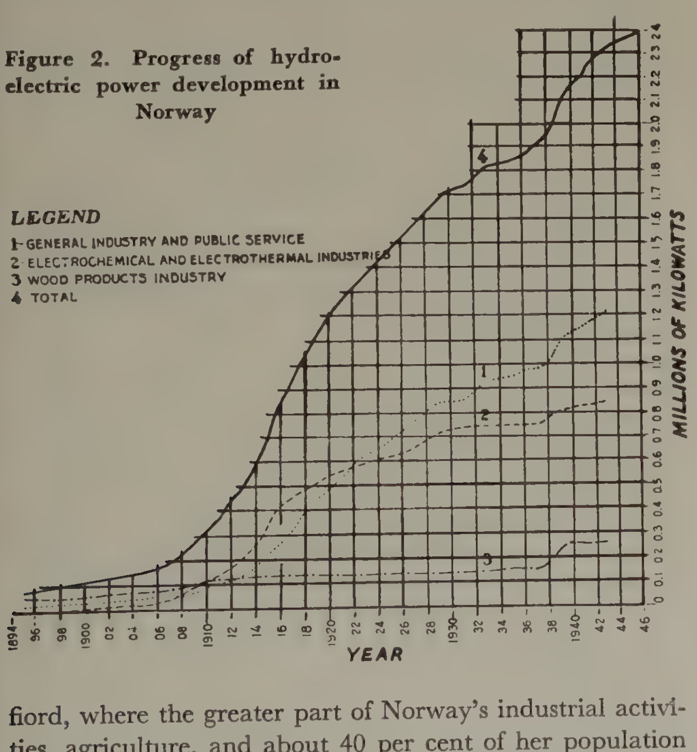
Aside from some fairly large isolated power developments in both countries operating at 25 cycles per second, principally for supply of power to electrochemical and electrothermal industries, the standard frequency in Scandinavia is 50 cycles per second.

POWER DEVELOPMENT AGENCIES

In Norway, private enterprise, communities, and the State are engaged in the realization and operation of water power resources. In general, plants built by private enterprise are constructed for the purpose of supplying energy to various forms of industry, such as pulp and paper, electrochemical, and electrothermal enterprises, while those built by city and district communities are designed for general public service, small industries, railway electrification, and so forth.

Largely because of the topographic limitations of the country, there is only one area with relatively thorough integration of water power resources, effected by interconnection of private, community, and state-owned generating stations and transmission facilities. This is the network serving southeastern Norway, in the area around Oslo

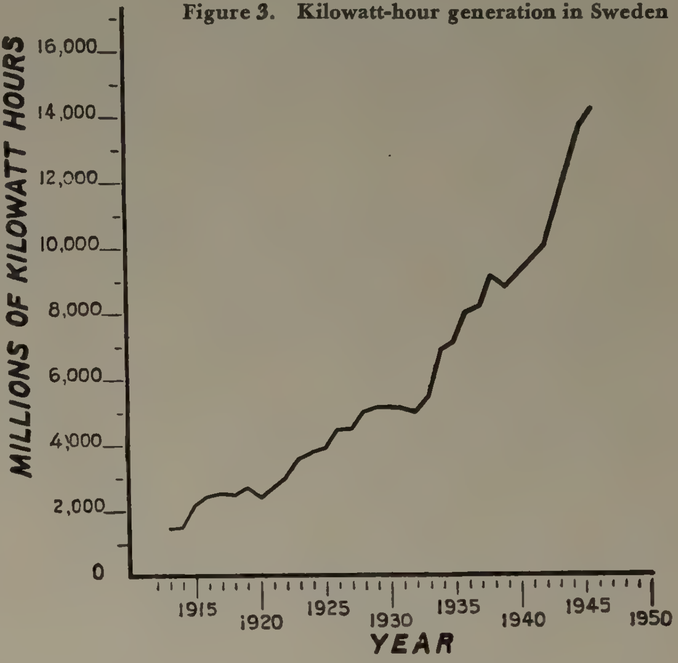
Figure 2. Progress of hydroelectric power development in Norway



fiord, where the greater part of Norway's industrial activities, agriculture, and about 40 per cent of her population are located.

In Sweden, as in Norway, private enterprise, municipalities, and the state have developed water power resources. In large part, those owned by private enterprise serve the power needs of large industries, particularly iron and forest products, and also supply energy for general usage in their logical territories, while those facilities developed by municipalities serve general industry and the public in their areas. Although the state had, in 1946, a total capacity of 900,000 kw in 20 large and a few small hydroelectric plants, as well as a 100,000-kw steam-turbine plant at Västerås, its

Figure 3. Kilowatt-hour generation in Sweden



primary concern is generation and bulk-power supply, largely to the area stretching from east to west around the great lakes in central Sweden and that part of Sweden north of the Indals River.

The largest municipal undertaking in Sweden is the Stockholm Electricity Works, with a total hydro capacity of 175,000 kw in three stations, a substantial share in Krångede A/B with 270,000 kw in two stations on the Indals River, and about 100,000 kw steam capacity. In 1946, generation was 890 million kilowatt-hours, used entirely in Stockholm.

The largest private power undertaking in Sweden is Krångede A/B, which is owned partly by some of the large industrial concerns in the mining districts of central Sweden, partly by Stockholm Electricity Works, partly by Sydsvenska Kraft A/B (serving southern Sweden), partly by Bergslagens Kraftförvaltning Gemensama, a distribution agency. It owns two power developments on the Indals River, and has a third under construction, with extensive 220-kv transmission facilities, supplying power to its owners. In 1946, it generated 2,100 million kilowatt-hours, or 15 per cent of total Swedish generation.

The power industry in Sweden is remarkable for the high degree of co-operation between private, municipal, and state power undertakings, as expressed in joint ownership of power plants and transmission facilities, very extensive interconnection, and voluntary co-operation to ensure the most efficient utilization of power resources. Practically all power plants are operated continuously in parallel, large-scale power interchanges taking place in accordance

with weekly schedules drawn up through intimate contact between the various interests, which is effected through what is known as the "central operating management." This practice was initiated voluntarily several years before World War II.

The State-owned power plants and transmission facilities are under the jurisdiction of the State Power Administration, organized and operated as an independent business concern. Its central or head office organization is the State Power Board in Stockholm, with district power administrations in seven important centers, and construction departments responsible for the construction of plants and transmission lines.

PHYSICAL AND HYDROLOGIC FEATURES

Norway is a long and narrow country occupying the western and northern side of the Scandinavian peninsula. Extending over 13 degrees of latitude, it has an area of 125,000 square miles.

Generally mountainous in nature, the slope to the west is relatively short and steep. To the east and southeast the slope is comparatively gentle. Central Norway is characterized by extensive and high mountain ranges, roughly flat-topped. On the west, numerous large fiords penetrate far inland, creating a very long coast line with fine natural harbors. On the east and southeast, deep valleys break up the level aspect of the mountain plateau. Much of this plateau lies above the timber line and is neither grass-covered nor barren. The whole country has been heavily glaciated. Even today, a number of glaciers on the western slope are larger than any others in Europe.

The headpiece is a view of the striking Sørfjord, with the penstocks of the 1,350-foot head Tysso I power plant visible on the right-hand shore, in the background. One of the better-known and more easily accessible glaciers is the Hardanger.

The character of the rivers in Norway shows great variations. Those draining to the west are relatively short, with small watersheds, their steep gradients giving rise to magnificent waterfalls, while those flowing to the southeast and east are much larger and longer. Although their gradients are flatter, there are some great waterfalls, such as the Rjukan Falls.

In Trøndelagan, the rivers are somewhat different from most of the west coast rivers, partly in that the slope of the land toward the great Trondhjem and adjacent fiords is easier so that the rivers have greater watersheds, partly the absence of high falls due to the softer geological structures.

In northern Norway, the rivers run in a northerly direction to the Arctic Ocean. Some of these are fairly large, due to the extensive, slightly rolling plateau.

Norway has many lakes, totaling about 5,100 square miles or four per cent of the area of the entire country. These lakes are of the greatest importance to the water power resources, as a great many can be economically utilized for water storage, thus smoothing out the variable flow of the rivers.

About 60 per cent of Norwegian water power is associated with heads of 1,000 feet or more.

In general, most water power sites in Norway are characterized by sound rock foundations. Many of the power developments involve tunnels for the conveyance of water; some of which are quite long. Rock formations ordinarily are so good tunnel lining is unnecessary.

Most Swedish rivers run in a generally southeasterly direction to the Baltic Sea. A few flow southwesterly to the Kattegatt. Of these, the most notable is the Göta, draining Sweden's largest lake, Vänern, whose most important tributaries run in a southeasterly direction. The Göta has a drainage area of some 19,350 square miles. No fewer than 11 of the 14 largest rivers, all with watersheds in excess of 3,850 square miles, are in northern Sweden. With a few exceptions, notably the Klara, emptying into Lake Vänern, the watersheds of Swedish rivers lie inside Sweden, the boundary between Norway and Sweden being fixed along a chain of mountains.

The area of Sweden is about 173,500 square miles. Of this lakes make up about nine per cent, forests 49 per cent, and mountainous districts 20 per cent.

In general the rivers have an irregular gradient, rapids and falls alternating with lakes and sluggish reaches. High falls are rare; the highest head so far developed is about 646 feet at Sillre. Average fall of the rivers ranges from as little as 2.33 feet per mile for the 50-mile long Fyrisån, through 5.12 feet per mile for the 270-mile Dal (longest river in Sweden), to 20.5 feet per mile for the 30-mile Lille Lule.

The foregoing will help to establish the basic elements underlying Swedish hydroelectric power developments: fairly low head, frequently less than 150 feet; relatively large flow.

In general, geological conditions are such that sound rock for power plant and dam foundations is found close to the surface. However, the country having been heavily glaciated, buried river valleys are not unknown.

PRECIPITATION AND RUNOFF

Precipitation in Norway is very unevenly distributed, as might be discerned from a study of the orographic features. Over much of the country the greater part occurs in the form of snow. Rain falls only during a few summer months in the mountain ranges. Snow occurs early in autumn and remains on the ground until spring and, in many areas, late summer.

The mild sea climate along the west coast and in southern Norway, due to the Gulf Stream, gives rise to rain throughout the whole year.

Precipitation varies greatly in different districts. Where moisture laden sea winds are forced to rise by the mountains, heavy precipitation results. This is particularly true in the vicinity of the great glaciers on the west coast. In such districts, an annual precipitation of the order of 115 inches has been observed. Runoff measured on one water course actually corresponds to an annual precipitation of some 235 inches over the whole catchment area. Minimum precipitation is found in the upper sections of the great valleys of eastern Norway where as low as 12 inches per year has been recorded. Comparatively low precipitation is found in northern Norway.

Runoff, as measured by the flow of Norwegian rivers, obviously varies widely. Records show that the average runoff for all Norway is about 3.3 cubic feet per second per square mile, ranging from 0.9 cubic feet per second per square mile to 18.3 cubic feet per second per square mile. The variation from year to year is about 70 to 130 per cent of the average, but in extreme years may be as low as 35 per cent or as high as 175 per cent. The extreme limits of observed annual runoff are 0.69 cubic feet per second per square mile and 30.3 cubic feet per second per square mile. Depending on the location, extent, and other features of the watershed, the low water runoff can fall as low as about one per cent of the average runoff, while the flood runoff may reach 2,000 per cent or more.

It will be appreciated that adequate storage-reservoir capacity is an essential feature of most Norwegian hydroelectric projects, readily available in many cases through utilization of the numerous lakes in a watershed. Developed storage at the end of 1945 totalled approximately 460 billion cubic feet.

Those streams which are fed by melting glaciers have quite a high and sustained summer runoff, due to the release of water stored in the glacial ice. However, this flow tapers off sharply during the winter season, so that ordinary storage is necessary for optimum sustained power.

At present, the glaciers in Norway, as elsewhere in the Northern Hemisphere, are retreating at an increasing rate, a fact which is causing considerable concern to those interested in hydroelectric power based in whole or in part on glacial streams.

For the period 1927 to 1935, the net loss of Norwegian glaciers has been estimated at 64 million cubic feet per square mile of glacier per year. During the glacier "budget" year 1946–47, the net loss was approximately 274 million cubic feet per square mile of glacier per year, or about 4.3 times as great as in 1927–35.

In Sweden, precipitation and runoff are, on the whole, much more uniform than in Norway. Average annual precipitation for all Sweden is about 22 inches, ranging from about 26 inches in southern Sweden to 20 inches in northern Sweden. The range for all Sweden between 1919 and 1945, inclusive, was 18.2 inches (in 1933) to 28.5 inches (in 1935). Evaporation in southern Sweden averages about 14.2 inches per annum.

River flow in southern Sweden is fairly uniformly distributed over the winter and summer six-months' periods. Rivers in northern Sweden show a marked fluctuation, with high summer flow and low winter flow, as would be expected.

The Lagan River in southern Sweden exhibits a summer flow about 60 per cent of the winter, and the Lule River in northern Sweden has a summer flow about 350 per cent of the winter flow. Storage is obviously necessary for optimum usage of available water. In 1946, the total capacity of reservoirs was about 850 billion cubic feet, or a storage of about 30 per cent of the 1946 kilowatt-hour generation.

SCOPE OF HYDROELECTRIC PROBLEMS

From the foregoing survey of factors affecting hydroelectric power development in Norway and Sweden, it will be apparent there is an extreme diversity of types of development.

Generating stations range from very low head and large discharge to very high head and small discharge; from Kaplan, through Francis, to impulse waterwheels.

In general, water storage is associated with most Scandinavian hydroelectric power plants today, being dictated by the fluctuation in water supply and the necessity of establishing a balance between water resources and load demand. Consequently the realization of adequate water-storage capacity adds to the diversity, as the storage capacity may be secured:

1. By raising the water level through construction of a dam at the outlet of the storage lake.
2. By drawing down the water level through a "tapping" tunnel driven into the storage lake at an elevation below normal water level.
3. By a combination of these methods.

While the transmission of power from the generating stations to the load centers, in Norway, does not involve great distances, it does entail very careful engineering because of the rugged terrain and severe climatic conditions encountered, particularly in respect to ice formation on the sections of transmission lines at high altitudes.

The transmission problem in Sweden is entirely different from that in Norway. Some 80 per cent of all water power resources are found in northern Sweden, which has about 15 per cent of the total population. Southern Sweden, with 85 per cent of the population and the major industrial area, has about 20 per cent of the power. Consequently, the development of Swedish water power is characterized by the great length of its transmission circuits from northern generating stations to southern load centers.

HYDROELECTRIC STRUCTURES

Norwegian practice in dam construction trends largely to reinforced concrete, as exemplified in the use of various types of arch and buttress dams. Basic reasons for this are

1. Location of dams in high mountain areas difficult of access, so that transportation of materials is an important cost factor.
2. General excellence of foundations.

Rockfill dams with thin reinforced-concrete core walls are used to a considerable extent for moderate heads. Gravity-type concrete or masonry-faced dams have been built in many instances where transportation costs were not too high and other features favored the gravity design.

Many of the buttress designs are enclosed on the downstream side with a relatively thin reinforced concrete curtain wall. During the winter electric space heating is employed, keeping the interior free from condensation, and eliminating contraction-joint leakage.

There appear to have been no unusual developments in connection with storage reservoirs during the last few years, beyond those inherent in lower cost dams and outlet works.

In Norway, many of the storages entail blasting out the tapping tunnel inlet into the lake, thus avoiding cofferdamming. This procedure appears to work out well, and is definitely economical.

In the low to medium-head plants in Norway, power

water is diverted through a headrace, intake structure with trash racks and control gates, penstock or other waterway, water wheel of the Kaplan, propellor, or Francis type (depending on head), draft tube, tailrace, and back to the original water course.

The high-head Norwegian power plants comprise, as a rule, an intake with trash rack and control gate, the intake frequently being located in the major storage reservoir but not necessarily so; pressure tunnel; surge chamber; at least two control valves, one of which is usually automatic, functioning when the penstock velocity exceeds a certain value, as well as suitable for remote control from the power plant, as may be the other; air-inlet (vacuum-breaking) valves; penstocks; penstock connections; water wheels; tailrace.

The highest head utilized in Norway is at Tyin, 3,540 feet gross, 3,199 feet net head. In this power plant, with its machine room stoped out of the solid rock of the mountainside, five horizontal impulse water wheels develop about 28,000 kw each at the 6,000-volt generator terminals. There is provision for a sixth unit. Figure 4 shows the arrangement of generating units in this plant.

By way of contrast, the lowest head developed in a Norwegian plant is somewhat less than 15 feet gross, at Fumefoss, on the Glomma River in southeast Norway.

One of the most interesting hydroelectric power developments in Norway is that whereby the Måna River, draining the great Hardanger plateau, is harnessed successively in the 34,000-horsepower Frøistul, 200,000-horsepower Vemork and 160,000-horsepower Såheim generating stations to supply the great nitrate industry at Rjukan. The watershed ranges from 580 square miles at Frøistul to about 610 square miles at Såheim and, with developed storage of 37.3 billion cubic feet, provides the station capacities noted.

Figure 4. Machine room of the underground Tyin power plant

Figure 5. View of Vemork power plant with electrolytic hydrogen plant in foreground

The gross head is 169 feet at Frøistul, 970 feet at Vemork, and 880 feet at Såheim.

Some idea of the physical features of the country which makes possible such power developments as those of the Måna River is afforded by Figure 5, a view of the Vemork power development and associated hydrogen plant. This plant was used by the Germans for the production of heavy water, and it was to cripple Vemork, and forestall the use of heavy water for atomic weapons, that a handful of daring saboteurs parachuted onto the Hardanger plateau, braving the bitter rigors of a winter in the high mountains, and after several months accomplished their mission.

The Såheim station in Rjukan is shown by Figure 6.

Another interesting Norwegian generating station is Søndenå, sometimes called Sauda III, shown in Figure 7. Here a watershed of 109 square miles, with developed storage of 5.5 billion cubic feet, yields about 1,130 cubic feet per second maximum flow, sufficient to warrant the installation of three 30,000-horsepower 500-rpm vertical Francis-type water wheels working under a gross head of 814 feet. The generators are rated at 26,500 kva, 12,500 volts, 25 cycles.

In Sweden the visiting hydroelectric engineer is impressed with the economy of material secured in some of the newer power plants, in the use of reinforced concrete for the waterways between headgates and turbines.

The highest head utilized in a Swedish power plant is about 646 feet at the Sillre power station on a tributary of the Indals river in Norrland (central Sweden). This plant is interesting in that it is designed for pumping water up to a storage reservoir during Sunday and holiday off-peak periods; the station being used for peak capacity.

One of the most interesting low-head power develop-

ments in Sweden is Vargon on the Göta River, at the outlet of Lake Vänern, where two outstanding large Kaplan runners, 26 feet 3 inches in diameter, develop 14,000 horsepower under 14-feet effective head, at a speed of 46.9 rpm.

Vargon is notable for other features than its extremely large Kaplan water wheels but, above all, for its simplicity. Trash racks are unnecessary due to the large water passages. As the intake is constructed as a syphon level with the maximum water level upstream, no headgates are needed. The flow of water is initiated by evacuating the syphon with a water-jet pump, and the generators are provided with removable sheet metal housings. Economy of concrete usage has been ensured, by careful blasting, through utilization of sound rock for much of the turbine pit and draft tube.

Figure 6. Såheim power plant

The largest hydroelectric plant is the Krångede station on Indals River with a total capacity of 210,000 kw. Here a head of about 195 feet and an average flow of 12,700 cubic feet per second, derived from a watershed of 7,900 square miles, is utilized by six units, of the vertical Francis type, rated at 35,000 kw each. The generators are designed for 8,000 to 9,250 volts, 50 cycles per second. The step-up transformers are 3 phase, 42,000 kva, 10/220 kv, connected directly to the respective generating units, without intervening low-tension circuit breakers. Transformers are air-cooled, with radiator-mounted fans as boosters. High-tension circuit breakers are 220 kv, air blast.

One of the notable advances made in the hydroelectric field in Scandinavia is the construction of underground power plants. This is particularly the case in Sweden, where at least ten important generating stations are located underground, with the machine rooms, penstocks or penstock shafts, draft tubes, and tailraces excavated out of solid rock.

A general idea of the design of such underground hydroelectric power plants can be obtained from Figures 8 and 9. It will be noted that the major element is usually a long tailrace tunnel designed for free flow. Further features of interest are the minimum rock excavation and usage of concrete. Careful drilling and blasting ensures removal of necessary rock only, and concrete is used where required for the supply conduit, water wheel setting, draft tube, and machine hall. However, the generator room frequently comprises only an arched roof sprung from the rock walls, reinforced-concrete crane girders and supporting columns, and floor.

Underground stations which the author has visited are fully as attractive as the best of surface stations anywhere (note Figure 4). This applies even where the rock walls simply are scaled and washed.

The adoption of an underground design for such important Swedish power plants as the 210,000-kw Krångede, 168,000-kw Hjälta, and 260,000-kw Hårspranget stations is founded on a sound technical basis. Such a design is economical for developments utilizing the power in relatively flat river reaches with slopes on the order of one in 50 to one in 100. It eliminates the necessity for a pressure tunnel or a headrace subject to site limitations and ice difficulties, and it also eliminates the usual form of penstocks.

In brief, three factors are predominant in their influence on the selection of the underground design:

1. Lower capital cost.
2. Lower operating and maintenance costs.
3. Military security.

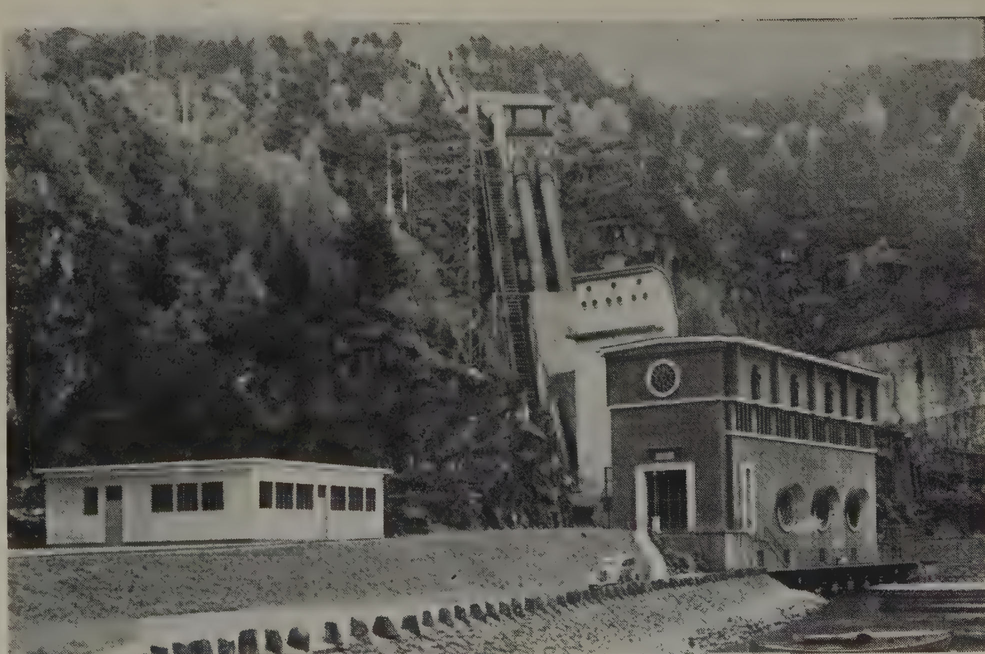


Figure 7. Søndena hydroelectric generating station

The lower excavation volumes, lower concrete requirements, and low-cost tunnel driving minimize capital expenditures, while low depreciation and maintenance costs on tunnels result in low annual costs. It may be of interest to note that the 4,180 feet by 540 square feet Porjus tailrace tunnels have required no maintenance in 35 years, and the 4,600 feet by 1,240 square feet Krångede tunnels have been trouble-free during more than ten years service.

Military security might appear, to the superficial observer, to be a controlling factor, but it actually is of less importance than technical and cost considerations. As proof, the Mockjard, Porjus, and Norrfors generating plants were constructed during 1907–11, 1910–15, and 1924–26, respectively, when military considerations were of minor importance, although this factor naturally is becoming of more importance, as demonstrated by the tendency to place the 220-kv step-up transformers underground.

Swedish underground generating stations, constructed or under construction, utilize gross heads of 78 to 403 feet. In this respect, they differ widely from two similar stations in Norway, Mår and Tyin, which operate at heads of 2,700 and 3,540 feet respectively.

The Mår generating station, not far from the Rjukan nitrate works of Norsk Hydro, utilizes 650 cubic feet per second (mean flow) to 970 cubic feet per second (maximum flow). Water is taken from a series of storage lakes, diverted from one watershed to another via several canals and lakes, thence through a 10.75-mile tunnel, with a minimum cross section of 215 square feet, to the surge chamber and two penstocks, about 4,100 feet long, carried inside a tunnel driven at a slope of about 40 degrees, thence to five 51,000-horsepower impulse turbines driving 40,000-kva generators. The machine room is excavated deep in the mountain side, the water wheel discharge flowing via a long tailrace, part tunnel, part open cut, to the Måna river. The 132-kv step-up transformers are installed in a transformer room located between the generating station and the mountainside. Switchgear is located in a surface switching station, shown in Figure 10 (note the reinforced-concrete structure).

Access to the station, which will be quite attractive when finished, is through a suitable tunnel with portal in the steep hillside.

Although conceived long before World War II, Mår generating station was placed under construction by a German occupation agency early in 1941. However, in July 1943, work was abandoned, without a single kilowatt-hour having been generated. Work was resumed shortly after the liberation and the first units should be in service soon.

The Tyin generating station is very similar to Mår except that the 110-kv step-up transformers are not placed underground. Figure 4 is a view of the machine room.

LOG FLOATING

The driving of logs for lumber and pulpwood is a very important usage of Swedish rivers, antedating power development. This, combined with the well-managed forest resources (49 per cent of the land is forested), means

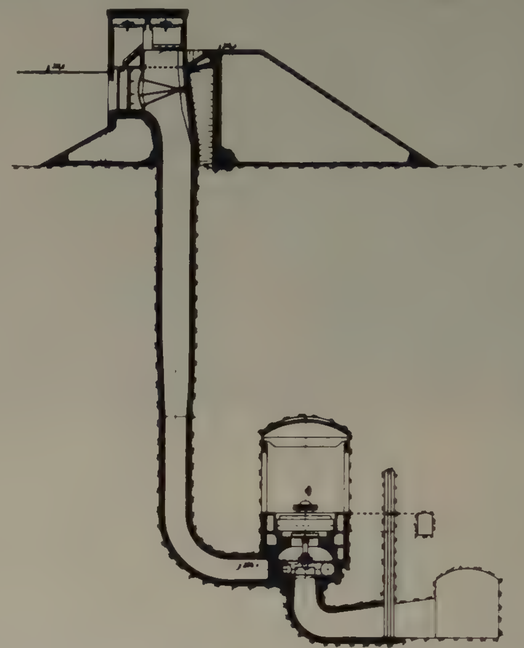


Figure 9. Cross section through a modern Swedish underground hydroelectric generating station

that adequate provision has to be made at virtually all power plants of any importance for the driving of logs. It is not surprising, therefore, that power interests in co-operation with logging interests have devoted considerable time, effort, and money to working out a solution involving minimum water usage for log driving.

One modern log-flume entrance at a Swedish power plant, comprises side walls constituting a bell mouth approach, which ensures that logs enter the flume with their major axis parallel to that of the flume. An adjustable floor, usually of timber, can be moved up or down so as to "skim" off a surface layer of water just deep enough to float the logs to the flume. The foregoing, combined with water jets or other devices to create a forward current in the surface layer conveying the logs, has

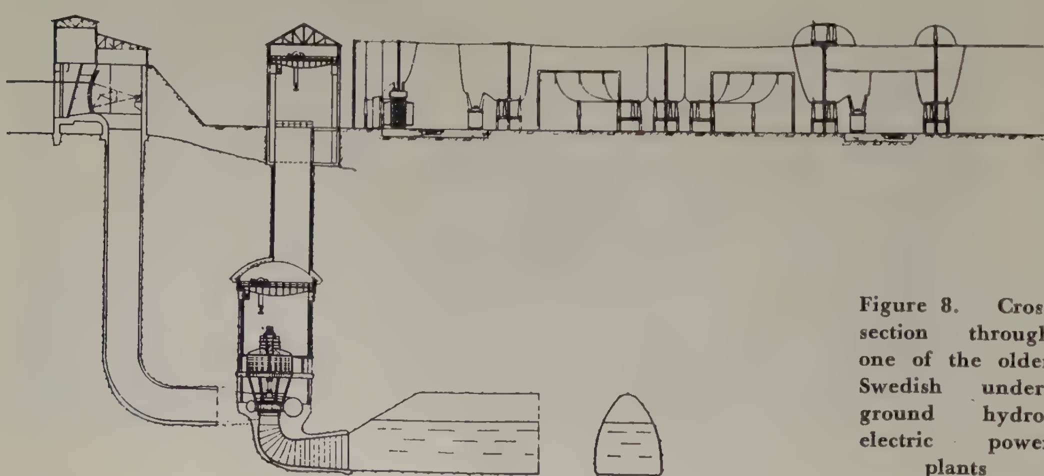


Figure 8. Cross section through one of the older Swedish underground hydroelectric power plants

enabled an hourly movement of 20,000 logs, between 21 and 27 feet long, with 425 cubic feet per second water.

Figure 11. Shop view of Krångede water wheel showing structural steel frame used to transfer loads due to generator and hydraulic thrust to foundations

ICE PROBLEMS

A troublesome operating problem with some hydroelectric power developments, in countries with a severe climate, is frazil ice. Frazil ice is essentially ice "needles" or crystals, about 0.04 to 0.08 inch thick and 0.75 inch long, which may be relatively dispersed or grouped in masses. Frazil ice occurs in waterways of such regime that a continuous ice sheet does not readily form, thus providing a heat-insulating medium between the water and atmosphere. The formation of frazil ice takes place when the water temperature drops from 32.11 degrees Fahrenheit to 32.09 degrees Fahrenheit and continues as long as the temperature remains at, or below, this level.

Various atmospheric conditions such as wind and temperature, clouds, and the like, play a very substantial part in the occurrence of frazil ice, which is generally most marked during the first severe cold spell in autumn or early winter before the formation of an ice cover. While obstructing the waterways, this ice exercises its greatest influence on power-plant operation through its tendency to adhere to trash racks and build up so much as to cut off completely the flow of water to the units.

Figure 10. The 132-kv Mår switching station

The basic factors controlling the presence of frazil ice above power-plant intakes have been recognized for many years in Scandinavia. As a result, power developments have been so constructed as to eliminate the frazil-ice problem to the maximum extent feasible. Technique employed has comprised:

1. Location of intake so as to draw off warm lower layers of deep storage.
2. Provision of approach waterways of such cross section a protective ice cover forms early in autumn and remains until spring.
3. Elimination of rapids above power-plant intake to maximum extent feasible.
4. Location of trash racks well below the surface so that the rack bars and structural members are not exposed to low atmospheric temperatures.
5. Heating the air space above the racks, if these are partially exposed.

However, where frazil ice cannot be avoided, electrically-heated trash racks are utilized almost universally in Scandinavia. The rack bars, making up the complete unit trash rack, are segregated into suitable groups through the use of oaken insulating supports. The bars in each group may be connected in parallel or some series-parallel combination, so that the necessary heating current can be circulated through the bars with a reasonable voltage, applied to the group terminals, from an insulating transformer.

Prior to 1924, seven Norwegian run-of-river plants, unusually susceptible to frazil-ice difficulties were able to avoid serious trouble by the use of electrically-heated trash racks with an input of 0.03 to 0.08 kw per square foot of exposed rack surface.

At the Trollhättan run-of-river plant on the Göta River, electrically-heated trash racks have been used for some years. The input has been reduced from the original value of 0.278 kw per square foot but 0.11 to 0.13 kw per square foot

has been found to be too low at the Hojum extension just upstream. At Älvkarleby, a run-of-river plant like Trollhättan, the input to the racks has been reduced gradually from 0.325 to 0.046 kw per square foot but some difficulty was experienced after six winters of successful operation at the lower input.

No difficulty from frazil ice is experienced with the hydroelectric plants in northern Sweden primarily because forebays and reservoirs are large and an ice cover forms quickly on the approach of winter.

Electric heating of various forms is employed successfully to maintain spillway gates, usually of the segment type, free of ice. One interesting device observed in Sweden is the application of heating current directly to the layer of reinforcing steel located about five inches from the side wall of the gate pier. The design contemplates the use of about 0.028 kw per square foot exposed concrete at −30 degrees to −35 degrees centigrade.

WATER WHEELS

The manufacture of hydraulic turbines in Norway has made tremendous strides since 1849 when a small Scotch turbine was built in Christiania (now Oslo). This same trend, of course, applies to water wheel manufacture in Sweden, Switzerland, France, United Kingdom, United States, and Canada, as well as Germany and Japan prior to World War II. It is perhaps more striking in Norway than elsewhere if one takes into account its relatively small population and limited heavy engineering industry.

In Norway, all types of water wheels are manufactured for home use and, to some extent, export. Perhaps the most outstanding Pelton or impulse units are the latest 1,125-feet-net-head 300-rpm 40,000-horsepower units for Nore. These comprise two wheels and twin jets per wheel, with so-called double regulation. The highest head on which a Norwegian-built impulse unit has been applied is 2,780-feet. Francis-type turbines have been manufactured for the vertical 60,000-horsepower 500-rpm 1,315-feet Höl (Ruud) station of Oslo Lysverk. Efficiencies achieved have been equal to, or better than, the best elsewhere: at Nore, 89.6 per cent; at Hygaard, on 738-feet head Francis units, 93 per cent; at Solbergfoss on three 11,500-horsepower 69-feet head Francis units 92 per cent, on four similar units 94.4 per cent, and on an eighth unit 96.4 per cent is claimed.

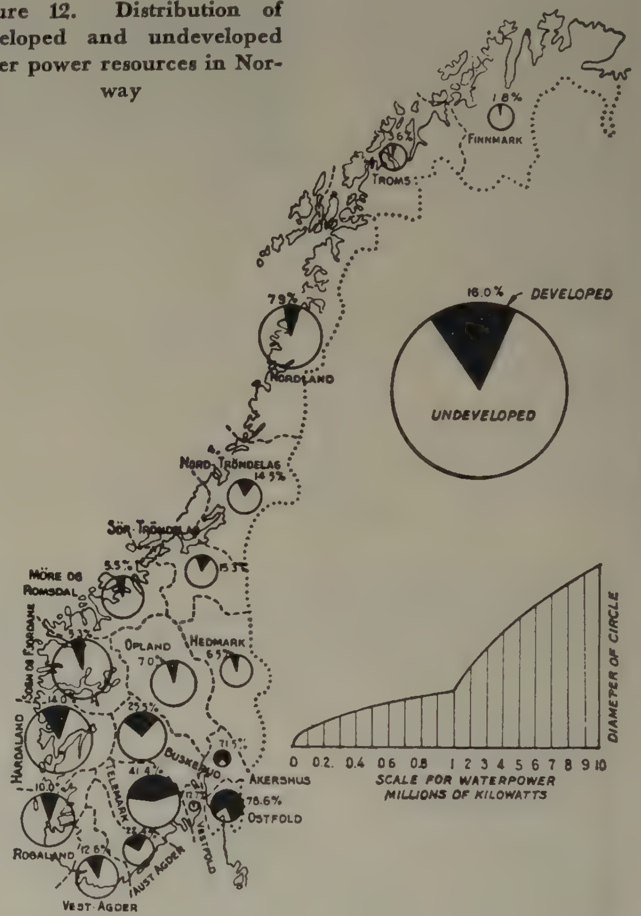
It is interesting to note that apparently the largest Norwegian water wheel builder has constructed no large completely cast Francis water wheels during the past ten years. Below a specific speed of 45 (English system), shaped blades (vanes) are assembled and the shroud ring and crown are cast about the blades. Above a specific speed of 45, shaped blades are welded to the cast shroud ring and crown. Not only does this procedure eliminate casting stresses in large runners and thereby the possibility of cracking—it simplifies manufacture and permits the use of runner vanes of the best alloy from the view point of resistance to cavitation damage.

In view of the low-to-medium heads associated with most Swedish water power, it is not surprising that Swedish turbine manufacturers have been closely connected with the development of the Kaplan water wheel. Many of the outstanding Kaplan installations in Europe use Swedish-manufactured turbines.

Among the more outstanding Swedish power plants with Kaplan water wheels are

1. Vargon—46.9 rpm, 14.1 feet net head, 15,200 horsepower, 26.25 feet diameter, and 160-ton runner. It is believed these are the largest in the world.
2. Lilla Edet—62.5 rpm, 18 to 23 feet net head, developing 11,200 horsepower at 21.3 feet head, 19 feet diameter, and 63-ton runner. Efficiency is 92.5 per cent maximum.
3. Stadsforsen—125 rpm, 65.6 feet net head, 40,000 horsepower; 65,000-horsepower over head range of 75.4 to 95.1 feet; efficiency 94.1 per cent maximum.
4. Hojum—136.3 rpm, 103.2 feet net head, 78,500 horsepower, operating at heads up to 109 feet.

Figure 12. Distribution of developed and undeveloped water power resources in Norway



Notable Francis-type water wheels built in Sweden include the Krångede units developing 54,000 horsepower at 189 feet net head and 166.7 rpm, with a maximum efficiency of 93.6 per cent. Swedish turbines built for export include the 100,000-horsepower 174- to 223-feet head 150-rpm turbines for the outstanding Genissiat power plant on the upper Rhone River in France.

GENERATORS

Perhaps the most outstanding feature of hydroelectric generator design in Scandinavia is the absence of standardization of terminal voltage. Usual practice is to select that voltage resulting in the most economical winding, usually somewhere between 9.8 to 11.8 kv. Some units are designed for 6.6 kv and there are a few 16-kv units in serv-

ice, as at Järpströmmen. The Hjälta and Harsprånget generators will be 16 kv, the latter rated 105,000 kva.

The use of mica insulation for the 9.8- to 11.8-kv generator stator windings is relatively recent, but no particular difficulties have been experienced during the six years or so that such insulation has been in use. However, considerable trouble was encountered with embrittlement of the organic insulation on the older 6.6-kv windings. In mica insulation, shellac or asphalt-bonded mica usually is applied with gas-heated or electrically-heated rolls and platens, and vacuum-pressure impregnation of the complete coils. The 16-kv Järpströmmen generator stator coils have a mica tape applied over the entire length, before vacuum-pressure impregnation.

For temperature indications, some operators specify thermocouples inserted on the copper of the neutral coils. Due to the long transmission distances involved in Sweden, most generators are designed for low transient and synchronous reactances.

It is to be noted the stator-core laminations are interleaved with thin paper insulation, with slightly heavier material in the middle of a lamination package. The use of heavy pressures and careful stacking results in cores free from waviness.

Most modern generators, both in Norway and Sweden, are water-cooled. In Sweden, the coolers ordinarily are attached directly to the stator frame, hot air being guided to the cooler, with outward discharge, the cool air recirculating back to either end of the rotor. This arrangement ensures minimum length of path for air flow. Coolers are designed for a ten degree centigrade differential between hot air and water. The preference seems to be for umbrella-type units with combined guide and thrust bearing below the rotor. Stator frames are fabricated rather than cast.

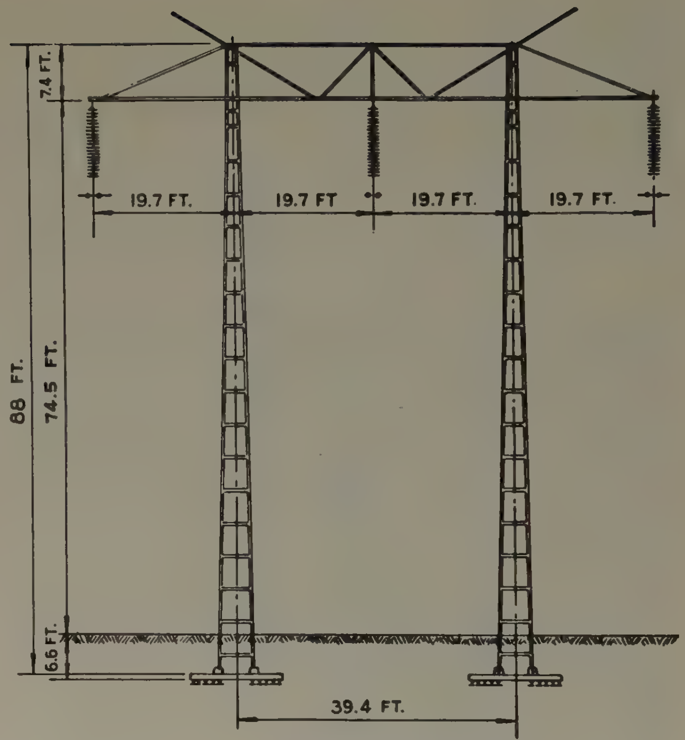


Figure 14. Transmission line tower for 380-kv line

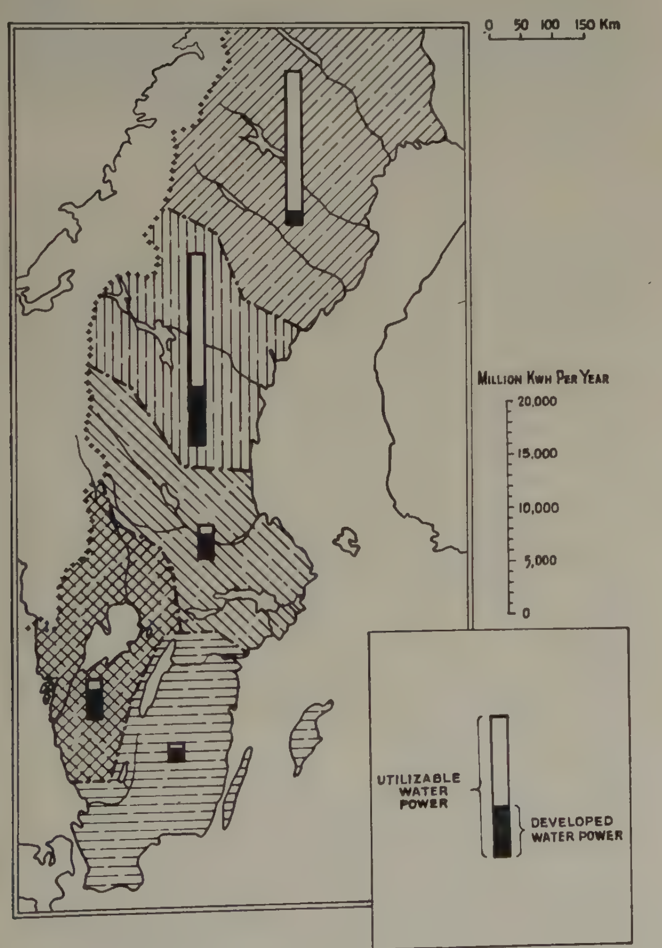


Figure 13. Distribution of developed and undeveloped water power in Sweden

An unusual feature at some power plants, such as Järpströmmen and Krångede, is the use of a structural-steel framework to transfer generator loading, including hydraulic thrust, to the scroll case and foundations. Figure 11 shows the method followed at Krångede.

Carbon-dioxide fire protection is used widely in Scandinavia. In Sweden, in some stations, carbon dioxide is released from storage cylinders by a bithermal relay, differential protection, and burning of an impregnated cord wound around end turns which, on rupture, releases a tripping relay.

The largest generators ever built in Sweden are the 16-kv 167-rpm low-transient-reactance amortisseur-equipped 105,000-kva Harsprånget units now under construction.

TRANSFORMERS

Developments in design and manufacture of power transformers in Scandinavia have kept pace with the growth in hydroelectric power generation, with the most notable advances taking place in Sweden.

As a result of substantial standardization on 220-kv transmission, most large power transformers have been constructed for this voltage. The range in capacity has been from 3,000 kva single phase to 120,000 kva 3 phase. These latter are outstanding in physical dimensions, being provided with three windings rated 120,000/120,000/40,000 kva, at 205/132/9.8 kv. The 132-kv voltage can be ad-

justed ±15 per cent in 18 equal steps under load. Total weight is 298 tons. Self-cooling is used at low capacity, with auxiliary cooling at higher loads.

The construction of the 380-kv 570-mile Harsprånget-Hallsberg transmission line, and the necessary terminal transformers, is leading to serious consideration of solidly-grounding the neutrals in place of using the Petersen coil, so widely utilized hitherto. However, it is planned to build the first 380-kv transformers with full insulation as insurance against switching transients, although the neutrals will be solidly grounded.

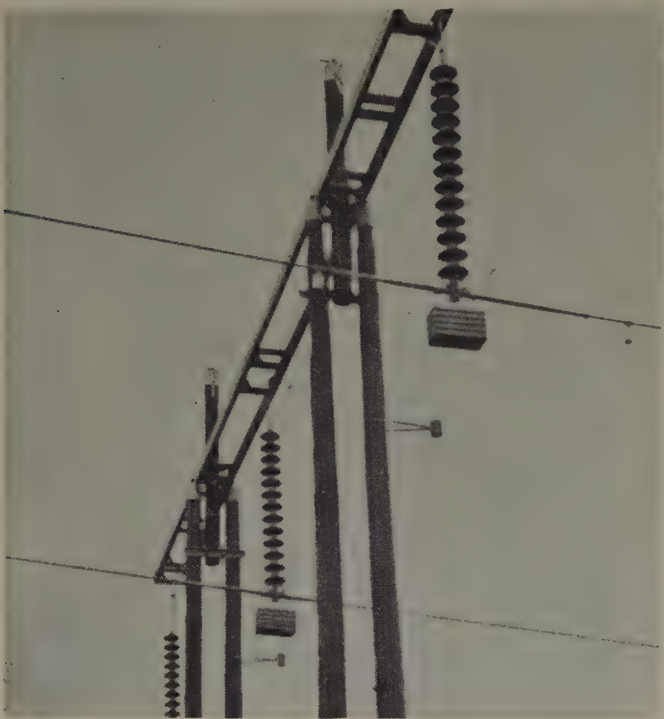


Figure 15. State Power Administration wood-pole 220-kv transmission line, showing ground wires, vibrator dampers, and weights insuring against conductor uplift

Bucholz (gas detector) relays are used widely, with uniformly satisfactory results. However, these relays ordinarily are placed in the conservator-tank connection. The extensive State Power Administration system employs these relays on all transformers rated 1,000 kva and higher.

Stabilized differential relays with compensation for in-rush current are used on major transformer banks, combined in many cases with back-up protection in the form of an overcurrent element in the stabilizing feature. Neutral current (residual) relays are used with Petersen coil protection.

Water cooling is preferred where water is available. Frequently very compact external oil-to-water heat exchangers are utilized. At Trollhättan the warm cooling water is circulated for house heating.

CIRCUIT BREAKERS

The trend in circuit breaker design is definitely in favor of air-blast circuit breakers. Oil circuit breakers, with limited oil content, will be restricted to transformer switching.

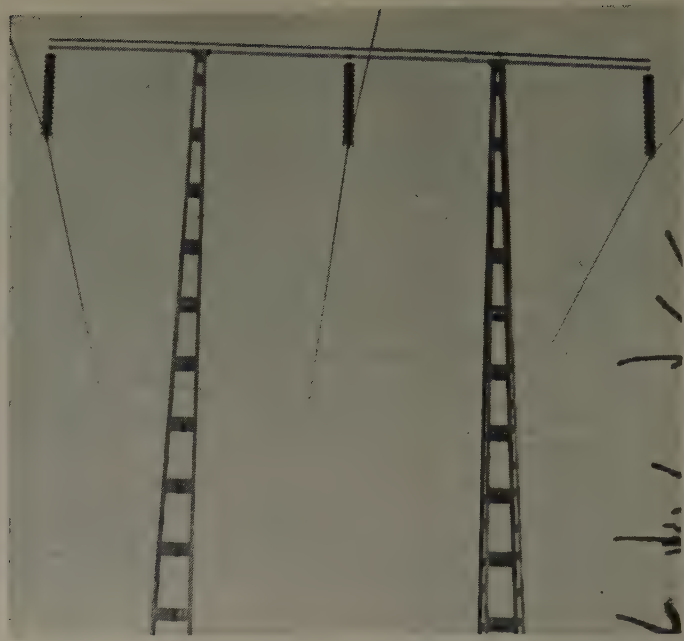


Figure 16. The 220-kv Krångede-Horndal transmission line

Present Swedish 220-kv air-blast circuit breakers have an interrupting time of 0.06 to 0.07 second. Automatic reclosure is effected in 0.25 to 0.30 second, with six to seven successful reclosures in 10 cases of trouble.

The construction of the 380-kv transmission line from Harsprånget is expected to result in considerable extension of air-blast circuit-breaker design and usage.

TRANSMISSION LINES

In Norway, transmission distances are relatively short, due to the excellent distribution of power resources with respect to load centers, shown by Figure 12. However, growth of demand in the area served by the interconnected system in southeastern Norway and around Oslo fiord succeeded in forcing the development of more remote water powers, with resultant longer transmission circuits. Thus, the output of the Höl power station will be delivered to Oslo over a 220-kv line some 115 miles in length.

The greatest problems transmission engineers have to contend with grow out of the severe topography of much of Norway—ice and snow deposits, and winter storms. Bad loading conditions exist in the coastal belt around southern Norway, as a result of sleet storms arising from moisture-laden air masses moving inland from the North Sea. Every four or five years, a fall of wet, heavy snow occurs in the low lands. Under the right temperature and wind conditions, this adheres to power and communication conductors, and may occasion a loading between four and five pounds per linear foot.

On the high-mountain plateau, a different type of ice condition occurs, the "voris" or weather ice. This results from water vapor, carried up relatively steep mountain slopes in warm, moisture-laden air rising from open lake and river waters in the deep valleys, condensing and freezing on conductors, insulators, and towers. Such deposits have been reputed to reach a thickness of six inches or more at altitudes over 2,500 feet.

Figure 17. A 12-kv transmission line with cast-in-place reinforced-concrete structures

The only permanent solution is careful selection of the route to be followed and heavy construction. It is considered that spans should not exceed 500 feet and that an ice loading of 14.75 to 37 pounds per linear foot at 0 degree centigrade should be allowed, which contrasts with the usual Norwegian allowance of about seven pounds per linear foot.

Transmission-line maintenance on the high plateau in Norway during the bitter early-winter storms is quite difficult. This is particularly true if "voris" formation is involved, as it has proved necessary, in some localities, to remove the tough ice by dragging ice-cutting tools along the iced conductors, using a cord of suitable insulating value, as the work must be done with the line hot. Moreover, such maintenance work necessitates climbing each tower, to pass the cutting tool by the insulator strings. Where such maintenance has to be carried out, it is necessary to maintain service men in camps about six miles apart.

In Sweden, the transmission problems are quite different from those in Norway. The most striking problem grows out of the fact that the major part of Swedish water power resources are located in the northern part of the country, whereas the major power-consuming areas are in southern and central Sweden. (See Figure 13.)

The consequence is that the power network in Sweden today reaches from Porjus in the north to Malmö in the south. In the north, it is interconnected with Norwegian hydroelectric stations at Narvik and, in the south, via 60-kv submarine cables laid under Öresund, with steam-power stations in Denmark. From north to south, the Swedish system stretches over 800 miles.

The backbone of the Swedish power network comprises five 220-kv transmission circuits, from Norrland to the south, with a sixth under construction.

Present plans call for the transmission of 3,000 to 3,500 megawatts south to load areas, by 1955, to meet rapidly-expanding loads. Average distance involved in this bulk-power transfer is about 420 miles with a maximum of 600 miles. The maximum extent of the network will be increased to about 840 miles.

As about 20 to 22 transmission circuits operating at 220 kv would be required to transmit the block of 3,000 to 3,500 megawatts, Swedish power interests long have sought a more economical transmission medium. Consequently, very considerable work has been done on high-voltage d-c power transmission. For this purpose a 90-kv experimental d-c transmission setup has been in use for two years between Trollhättan and Mellerud, a distance of about 31 miles. While results have been encouraging, the need for additional transmission capacity quickly has resulted in a decision to transmit the output of Harsprånget power development, near Porjus on the Lule River, via Nidakog on the Indals River, to Hallsberg at 380 kv, a distance of 570 miles.

This is practical, from the stability viewpoint, because Midskog power development is tied in with a very substantial block of generating capacity at several plants on the Indals, in Norrland, about midway between the line terminals.

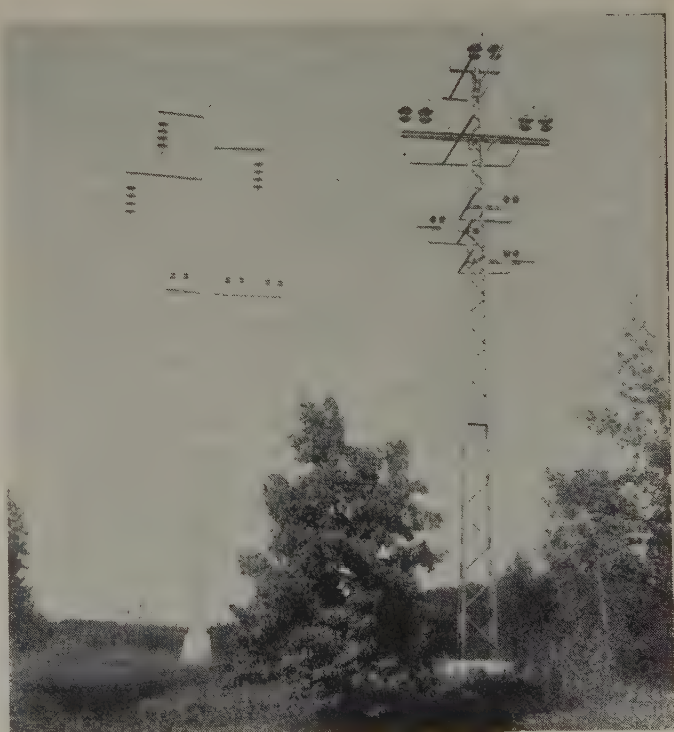


Figure 18. Reinforced-concrete structure carrying 60-kv transmission circuit

Towers to be used on the 380-kv line are shown by Figure 14. They weigh about 7.05 tons. Twin conductors per phase (split-phase) will be used, the separation between the two conductors of a phase being about 17.75 inches. They will be ACSR, 250-square-millimeter copper equivalent. The neutral of the terminal transformer banks will be solidly grounded, although the transformer windings will have full insulation. The transmission line is expected to be in service by the end of 1950. ACSR is used almost universally in Sweden, copper having proved unsatisfactory for 220-kv circuits because of strand failures.

Although three of the existing 220-kv lines were built by the State Power Board and the other two by private and municipal electricity undertakings, legislation adopted in 1946 provides for the construction of all new transmission lines, at 220 kv or higher voltages, by the State, in the interest of co-ordination, although all interested parties had worked out a satisfactory scheme for construction and ownership of such lines by a joint-stock company with majority holding vested in the State Power Board.

It might be noted here that major transmission voltages in use today, aside from 220 kv, are 132, 77, and 55 kv. Historical background is largely responsible for the particular voltage used in a given area.

Swedish transmission engineers have developed simple, low-cost structures of very satisfactory performance and pleasing appearance, as shown by Figures 15 and 16. Steel towers for 220-kv lines are comprised, in the more modern designs, of two latticed, welded upright members and a third horizontal member. Creosoted sleepers or bearing members are used under footings. Lightning is not severe, causing about 0.9 flashovers per 100 kilometres (60 miles) per year, about 50 per cent of which are cleared by the Petersen coil used in transformer bank neutrals. Conductors usually are strung to not exceed 50 per cent of the ultimate stress under loading. Armour rods are used to quite an extent.

Where wood poles, mostly Swedish pine, are used it has been standard practice in Sweden to use creosote preservative. During World War II creosote was in short supply, so that arsenic, of which large quantities are produced in Sweden, was used in both open-tank and vacuum processes. Although the arsenic impregnation has proved very satisfactory in seven or eight years of service, it is not entirely safe, as the "salty" flavor tends to attract cattle. As a result, it is proposed to use arsenic in combination with a creosote surface treatment.

An interesting Norwegian development in the transmission field is the use of reinforced concrete structures up to 220 kv. Figures 17 and 18 illustrate examples of concrete structures for moderate voltages. Figure 17 shows a structure which is cast-in-place, a technique used to quite an extent in Norway.

The Oslo Lysverk, it is understood, is carrying out experiments with 220-kv concrete transmission on-line towers, a natural move in view of the fact all structural steel has to be imported into Norway whereas cement does not. It is understood that the cast-in-place concrete structures, which have a very good service record, cost somewhat less than steel, at 60 kv and above.

The Radio Telescope

A radio telescope has been designed and is being assembled by Cornell University engineers. Analogous to an optical telescope, it has a 17-foot parabolic reflector mounted on a polar axis which will follow the motions of the sun and stars. Instead of visual or photographic observation, the information is obtained from a sensitive receiver fed by a small antenna at the focal point of the reflector. To be used under all types of weather conditions, the telescope will be used in a radio astronomy investigation jointly sponsored by Cornell University and the Office of Naval Research.

Designed to withstand winds up to 60 miles per hour and to track with an angular error of less than one-half degree, the telescope will see areas of the sky whose diameter varies from about two to 30 degrees, depending on the frequency employed. In addition to the usual astronomical polar and declination axes, there are two other rotations available—one about a vertical axis to facilitate calibration of the antenna, the second the rotation of the reflector about its own axis for polarization studies.

The sun radiates at all frequencies of the electromagnetic spectrum. The radiation at the radio frequencies is too weak to be detected by commercial broadcast receivers, but occasionally presents interference in the form of static to the shorter wave bands. This static from the sun and other sources in space, which arrives at the surface of the earth, is the subject of the radio astronomy studies.

The earth's atmosphere is transparent to electromagnetic radiation near the visible portion of the spectrum Through this window, approximately one decade broad, man has obtained virtually all of his knowledge of the universe. It is through a second window, three decades wide, located in the shorter wave radio region of the spectrum (20–30,000 megacycles), that the information from outside the earth called static or noise is to be observed.

As pointed out earlier, the radio telescope is analogous to an optical telescope. There are, of course, important differences. While refering to the instrument as a radio telescope, it is both a telescope and spectograph as it accepts only a bandwidth of frequencies of the order of a megacycle. The radio telescope antenna, for both structural and economic reasons, must be limited in size to same order as the wave length of the incoming radiation. (At 10-centimeter wave length the 17-foot parabola corresponds to about 50 wave lengths.) The radio telescope has an angular resolving power of the order of degrees compared with tenths of second of arc for optical telescopes.

Astronomical telescopes ordinarily record radiation of all polarization indiscriminately, are sensitive to a large fraction of the optical range of frequency, and use receivers such as the photographic plate which integrate the effects over times the order of hours. In contrast to this, the radio telescope has a preference for one plane of polarization, accepts only a small range of frequencies, and integrates the effects over periods of the order of seconds or less.

Aircraft Reverse Current Cutout

J. M. MARZOLF
ASSOCIATE AIEE

THE FOLLOWING CIRCUIT is proposed for an aircraft reverse-current differential cutout. It consists of two units outlined by the dotted lines in Figure 1.

To explain its operation, assume that the main contactor is open and the generator voltage is zero. In this condition, both the triple-pole double-throw switch associated with the main contactor, and the permanent magnet control element will be in the upper position as shown in Figure 1. When the generator voltage increases to approximately 20 volts in the proper direction, the polarized auxiliary relay in the differential coil circuit closes, thus making the cutout operative. Since the battery voltage, however, is still higher than the generator voltage, current will flow through the differential coil in the reverse direction, holding the permanent magnet in the original position, and the cutout will not close. When the generator voltage becomes slightly higher than the battery voltage, the flux from the differential coil is sufficient to overcome the residual flux in the magnetic core of the control element. This causes the permanent magnet to rotate and make instantaneous closure with the lower contact, causing the thyratron to fire continuously regardless of subsequent grid voltage. This causes the pilot relay and the main contactor to close, and the pilot relay is locked in by its holding coil. When the main contactor closes, it mechanically throws the auxiliary contacts to the lower position and, in passing from one position to the other, instantaneously opens the plate circuit of the thyratron, extinguishing it, but the pilot relay and the main contactor remain closed.

When reverse current flows from the battery to the generator, the voltage drop across the generator series field is impressed on the reverse coil of the permanent magnet control element, causing the magnet to rotate to the upper position and the thyratron will fire again. The plate current passing through the operating coil of the pilot relay in the opposite direction overcomes the holding coil and allows the pilot relay and main contactor to open. As the main contactor opens, it mechanically returns the auxiliary contacts to the upper position and, in so doing, interrupts the thyratron current long enough for the tube to be extinguished, and the cycle can be repeated.

The purpose of the residual coil is to restore the residual flux in the magnetic core of the control element and thus insure that it will operate at the same point each time. In addition a high value of residual flux is guaranteed to prevent spurious operation under conditions of shock or vibration at no-load conditions.

The ballast lamp serves only to protect the heater of the thyratron tube and prevent damage under the wide variations of terminal voltage that must be tolerated.

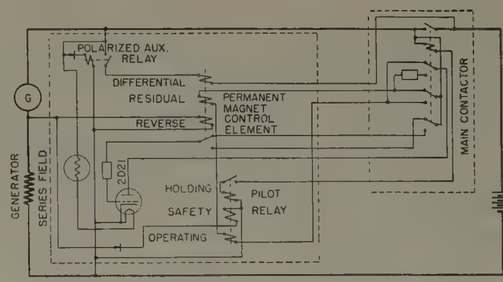


Figure 1. Circuit diagram for proposed reverse-current cutout

The safety coil on the pilot relay is included to insure that the cutout "fail-safe" and would operate the pilot relay only under large reverse currents if the thyratron tube were to burn out while the cutout was closed.

A properly designed cutout based on this principle would be practically independent of temperature, altitude, and terminal voltage (from 20 to 30 volts). The same cutout could be used on any aircraft 28-volt d-c system regardless of generator rating. The components may be located remotely for convenience, accessibility, and so forth. It could be constructed as a plug-in unit to be removed and a new one installed quickly in case of failure. The power loss is low since no shunts are required in the power circuit. There are no restraining springs on the permanent magnet, thus it can be made quick-acting and will not be subjected to fields which might reverse its polarity accidentally.

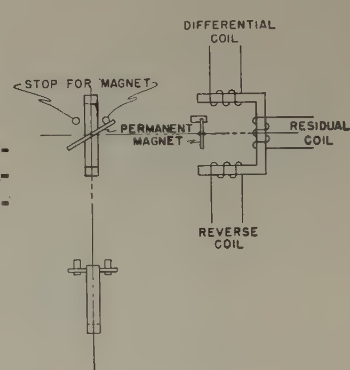


Figure 2. Schematic representation of magnetic circuit of control element for proposed reverse-current cutout

Since no attempt was made in the mechanical design of the experimental model to take care of the factors of vibration, shock, changes in physical dimensions due to temperature, and so forth, no tests were performed under actual operating conditions, but sufficient trials were made to convince the author that the principles involved are sound, and that a properly designed cutout based on these principles would be entirely satisfactory under the extremely wide variations of conditions encountered in aircraft.

Digest of paper 48-223, "Proposed Circuit for Aircraft Reverse-Current Cutout," recommended by the AIEE air transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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3-Conductor Cable Resistance and Inductance

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IN STUDYING the general problem of weight reduction in shipboard equipment, consideration has been given to the use of higher frequency power. This has required an investigation of the operating characteristics of 3-conductor cables. The characteristics of interest are the effective or a-c resistance and inductance when the cable is operated in a 3-phase circuit.

The skin effect in isolated conductors more commonly is encountered and formulas have been derived which will permit the calculation of effective resistance of certain shapes of conductors to any degree of accuracy desired. Experimental verification of these equations has been made by several investigators. However, less attention, both experimental and theoretical, has been given to the case of skin effect in conductors in close proximity. Equations for the skin effect in two closely spaced round wires in a single-phase circuit and three equally spaced round wires in close proximity in a 3-phase circuit, have been derived by H. L. Curtis and H. B. Dwight, using dissimilar methods.

In the case of two closely spaced wires, Curtis has shown that the formulas give results which closely check the experimental data. No experimental verification of the formulas for three conductors in a 3-phase circuit seems to have been made. However, measurement of effective resistance and inductance of 3-conductor underground power cables have been made at about 60 cycles per second.

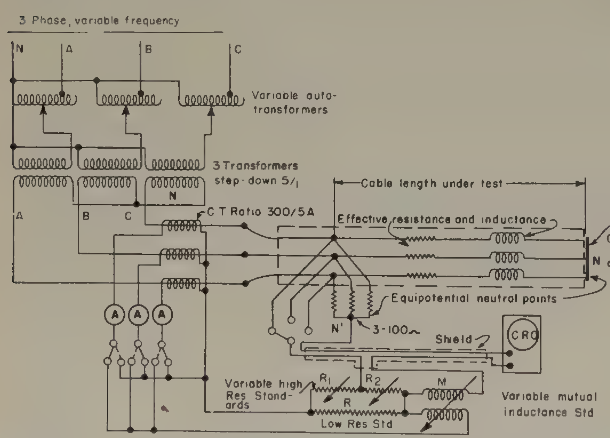

Figure 1. Circuit diagram for the measurement of the effective resistance and inductance of a 3-conductor power cable

Although skin effect formulas for isolated round wires have been shown experimentally to be applicable to stranded conductors of equal area without serious error, no proof has been given that similar extrapolation can be made in the case of a 3-conductor cable when operated in a 3-phase circuit. Also, it is known that the effective resistance and inductance of a cable are affected by the armor and conducting sheath material. For these reasons it seemed necessary to obtain the effective resistance and inductance of the cables in question by experimental means.

Tests were conducted on cable lengths of approximately 25 feet, using 3-phase currents at frequencies up to 800 cycles per second.

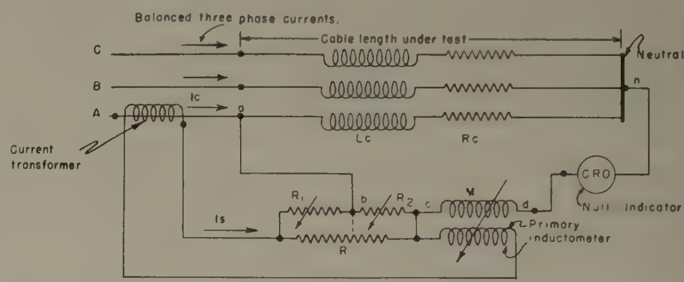

Figure 2. Basic circuit diagram for the measurement of the effective resistance and inductance of a 3-conductor cable

The cables tested were selected to demonstrate the effect of the following factors on the effective resistance and inductance of the cable:

1. Conductor separation or spacing.
2. Conductor size.
3. Cable armor.
4. Adjacent steel supporting plates.
5. Conductor grouping in the case of a 6-conductor cable when operated in a 3-phase circuit.

The results of the tests indicate that

1. The effective resistance of the cable increases rapidly as the conductor separation is reduced.

2. The skin effect resistance ratio increases more rapidly for large than for small conductors as the frequency increases and the effective inductance decreases more rapidly for large than for small conductors as the frequency increases.

3. Steel armor on a cable causes an increase in the effective resistance and inductance of a cable.

4. The effective resistance and inductance of a cable is increased by steel plates on which the cable may be mounted.

5. The effective resistance and inductance of a 6-conductor cable is lower when the two diametrically opposite conductors are operated in parallel in a 3-phase circuit than when the two adjacent conductors are operated in parallel. The first grouping has lower effective resistance and inductance than 3-conductor cables of larger conductor area.

Precision of instruments used assures a maximum error of one per cent in measurement of effect resistance.

Digest of paper 48-246, "Effective Resistance and Inductance of 3-Conductor Shipboard Power Cables," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in the AIEE *TRANSACTIONS*, volume 67, 1948.

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Mathematics for Engineers—III

Dimensional Analysis of Partial Differential Equations

GARRETT BIRKHOFF

This third and concluding part of a series presents methods of attacking certain difficult problems by applications of dimensional analysis. The articles in this series are being made available in pamphlet form and will be announced as soon as available.

IT IS MY PURPOSE to show that many physically important special solutions of partial differential equations can be obtained by a direct generalization of dimensional analysis to the mathematical concept of a group. As most engineers are already familiar with the concept of dimensional analysis, and the associated concepts of scale models and similitude, this principle should be of considerable use. I hope that it incidentally will persuade some readers to become acquainted with the group concept.

In fact, the principle has been used implicitly so many times by engineers and mathematical physicists, that I am convinced some of them really must have had the idea of a group in the back of their minds.

Let me first recall some basic principles of dimensional analysis. In this subject, one postulates that certain fundamental units, $q_1, \ldots, q_r$, can be changed in any positive ratio by transformations of the form

$$\alpha: \; q_i' = \alpha_i q_i \qquad (\alpha_i > 0;\; i=1, \ldots, r) \tag{1}$$

called "changes of scale." One then considers homogeneous quantities $Q_1, \ldots, Q_m$, which are transformed under equation 1 by

$$Q_j' = \prod_{i=1}^{r} \alpha_i^{c_{ij}} Q_j \tag{2}$$

Thus typically, the q_i might be length, time, and mass; while the Q_j might be density, energy, or viscosity. Each Q_j is said to have dimensions $q_1^{c_{1j}} \ldots q_r^{c_{rj}}$; in most applications, the c_{ij} are integers (or half-integers).

An equation or other relation is said to be unit-free, if and only if it is valid in all sets of fundamental units, or "systems of measurement." The most important theorem of dimensional analysis is the celebrated "pi theorem" of Buckingham, which asserts the following. Let an equation

$$(Q_1, \ldots, Q_m) = 0 \tag{3}$$

be unit-free and involve the r fundamental units $q_1, \ldots, q_r$. Then equation 3 is equivalent to an identity

$$g(\pi_1, \ldots, \pi_{m-r}) = 0 \tag{3a}$$

between $m-r$ dimensionless power-products $\pi_k = Q_1^{\beta k1} \ldots Q_m^{\beta km}$ of the Q_j—A "dimensionless" power-product is of course simply one which is invariant under all transformations of the form 1.

Although the usual proofs[1] of the pi theorem make the assumption that f can be expanded in power series, in fact no restriction on f is necessary. As it is doubtful whether most of the empirical functions involved in the practical applications of dimensional analysis can be expanded in power series about $Q=0$, this point seems to be of some importance.

Before generalizing dimensional analysis, let us consider a typical application of ordinary dimensional analysis to the equation of heat conduction in solids.

$$\frac{\partial U}{\partial t} = K\nabla^2 U = K\sum_{i=1}^{n} \frac{\partial^2 U}{\partial x_i^2} \qquad (n=1,\, 2, \text{ or } 3) \tag{4}$$

Here the coefficient K of thermal diffusivity has dimensions LT^{-2}; this may be verified physically,[2] or more simply by noting how equation 4 transforms under a change

$$r \rightarrow \alpha r,\; t \rightarrow \beta t \tag{5}$$

of space–time co-ordinates.

Suppose we are interested in the diffusion of heat from the center of a sphere of arbitrary diffusivity coefficient K and diameter D, in a variable time T. The pi theorem tells us that for physically different spheres, this must be a function of the single "dimensionless parameter" $\pi = KT^2/D$. If we are distrustful of dimensional analysis, we can transform explicitly by expression 5 to the case of $T=1=K$ and $D=1/\pi$. Thus by use of similitude (dimensional analysis), we have reduced the number of physical parameters which need be considered.

Again, for any given sphere, the amount of diffusion to all points at a fixed distance from the center of the sphere in a given time is the same, by spherical symmetry. Hence we have

$$U = U(KT^2/D;\; r/D)$$

and not merely

$$U = U(KT^2/D;\; x/D, y/D, z/D)$$

as we would have in the case of a solid of general shape. Again, we have reduced the number of variables involved by (obvious) use of similitude.

It will be noted that in the last example, although the transformations of similitude (rigid rotations) were a 3-parameter family, the number of variables involved was reduced only by two. Whereas in the pi theorem, the number of variables always is reduced by exactly the number of degrees of freedom in the choice of fundamental

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units. I shall state later a "generalized pi theorem" which in fact includes both results.

The consideration of spherical symmetry also involved a self-similitude, whereas the preceding application of ordinary dimensional analysis involved similitudes between physically distinct cases; this is why we spoke of reducing the number of "variables" in one case, and of "parameters" in the other.

I now come to the novel use of dimensional analysis, or more accurately of symmetry considerations. In the case of an infinite solid (conical or without boundary), the solid and differential equation (4) are invariant under the one-parameter family (actually, group) of self-similitudes.

$$r' = \alpha r,\ t' = \alpha^2 t,\ U' = \alpha^m U \tag{5a}$$

for any positive number m. We now look for solutions of equation 4 possessing the symmetries of the problem. In the present case, we wish them to be spherically symmetric and invariant under equations 5a.

Spherical symmetry amounts to setting $U = U(r;\ t)$; by the pi theorem, we then have two dimensionless variables: $\chi = r^2/t$ and $V = U/t^{m/2}$. Hence $V = F(\chi)$, and so

$$U = t^{m/2}F(r^2/t) \qquad \chi = r^2/t \tag{6}$$

Our general principle, to be stated later, asserts that equation 4 will have solutions of the self-symmetric form of equation 6.

Knowing that the solution exists, it is easy to find it. We obtain the ordinary differential equation satisfied by $F(\chi)$, by the following series of direct computations, in n dimensions:

$$\frac{\partial U}{\partial t} = t^{(1/2)m-1}[(1/2)mF - \chi F']$$

$$\nabla^2 U = \frac{\partial^2 U}{\partial r^2} + \frac{n-1}{r}\frac{\partial u}{\partial r} = t^{(1/2)m-1}[4\chi F'' + 2nF']$$

Equating and dividing out a suitable power of t, we get

$$4K\chi F'' + (2Kn + \chi)F' - \frac{m}{2}\ F = 0 \tag{7}$$

Since this is an ordinary differential equation, it easily can be integrated numerically, for any real m, and "initial values" of F and F'.

However, not all these "symmetrical" solutions have equal physical interest. Interest largely is confined to solutions for which $U \to 0$ as $r \to \infty$, so that

$$\lim_{x \to \infty} F(\chi) = 0$$

We also are interested in the total heat, which is proportional to $\int_0^\infty Ur^{m-1}dr$,and hence to $\alpha^m\alpha^n = \alpha^{m+n}$, or to $t^{(m+n)/2}$.

One special case of interest is constant total heat, corresponding to diffusion of a fixed quantity of thermal energy, initially at the origin. Here $m = -n$; if we set $n = 2h$, equation 7 reduces after collecting terms to

$$\chi(4KF' + F)' + h(4KF' + F) = 0 \tag{8}$$

One solution (the simplest) is

$$(F\chi) = e^{-\chi/4K} = e^{-r^2/4Kt}$$

whence

$$U = Ct^{-n/2}e^{-r^2/4Kt} \tag{9}$$

Another interesting case is a point source producing heat (by chemical or radioactive process) at a constant rate, beginning at $t = 0$. Here $m + n = 2$, or $m = n - 2$, whence equation 7 becomes

$$4K\chi F'' + (4Kh + \chi)F' + (1 - h)F = 0 \tag{10}$$

The integrals of this, obtained by other means, may be found in paragraph 104 of reference 2; the case $n = 2$ is especially obvious, as then $(1 - h) = 0$.

To summarize: Invariance of the heat equation under expression 5 is a matter of simple dimensional analysis; looking for solutions invariant under equations 5a corresponds to writing equation 6; once we have written this, the rest is simple.

Exactly the same procedure is possible with the classical wave equation. The analogous formulas are

$$\frac{\partial^2 U}{\partial t^2} = \nabla^2 U \tag{11}$$

which is invariant under the substitutions

$$r' = \alpha r,\ t' = \alpha t,\ U' = \alpha^m U \tag{12}$$

So is U if

$$U = t^m F(r/t) = t^m F(\chi) \qquad (\chi = r/t) \tag{13}$$

By direct computation, equation 11 is equivalent in equation 13 to

$$(\chi^2 - 1)F'' - (2m - 2)F' + m(m - 1)F = 0 \tag{14}$$

Here the differential equation has a singularity on the so-called characteristics $\chi = \pm 1$ $(r = \pm t)$ of the equation; the interesting solutions are those which behave suitably there.

In the case of the Laplace equation $\nabla^2 U = 0$, the analogous group is $r' = \alpha r$, $U' = \alpha^m U$. For U to be invariant under this group, and not under spherical symmetry, we set $U = r^m \mathrm{F}(\phi,\ \theta)$. As is well-known, this leads to the definition of spherical harmonics.

To show that the utility of looking for "symmetric" solutions is not confined to easy problems, I shall take my next example from that notoriously difficult subject, the theory of viscous incompressible fluids.

In the plane, we can introduce a "stream function" V, defined by making $(-\partial V/\partial y,\ \partial V/\partial x)$ the velocity vector; $\nabla^2 V$ is then the vorticity. This is well-known, and the differential equations of motion can be compactly written, using Jacobian notation, in the form[3]

$$\nu\nabla^4 V = \frac{\partial(V, \nabla^2 V)}{\partial(x, y)} = \frac{1}{r}\frac{\partial(V, \nabla^2 V)}{\partial(r, \theta)} = \frac{1}{r}\left[\frac{\partial V}{\partial r}\frac{\partial(\nabla^2 V)}{\partial \theta} - \frac{\partial V}{\partial \theta}\frac{\partial(\nabla^2 V)}{\partial r}\right] \tag{15}$$

Here ν is the kinematic viscosity = viscosity ÷ density = μ/ρ; it occurs in the well-known definition of the Reynolds number $R = vd/\nu v$(= typical velocity, d = typical length).

Dimensional analysis tells us that under geometrically similar conditions, the behavior of incompressible viscous fluids will be a function of the single dimensionless parameter R, which plays the role of KT^2/D in the preceding example. We now look for self-similar plane motions.

To this end, we consider the spiral group

$$r'=e^{\alpha}r, \qquad \theta'=\theta+c\alpha \tag{16}$$

where the parameter c is a fixed real number.

The transformations (16) are self-similitudes of space; since v is fixed, they will make the motion self-similar at the same R, if and only if rv is the same at corresponding points. That means that differences in V [which are proportional to distances times velocity, since $dV=\mathrm{re}\,(\partial V/\partial x)dx+(\partial V/\partial y)dy$] must be invariant under the spiral group (9). Hence

$$V(e^{\alpha}, \chi+c\alpha)-V(e^{\alpha}, c\alpha)=V(\chi, 1)-V(1, 0)=F(\chi) \tag{17}$$

is a function of χ alone, for any α. By similarity also, $V(e^{\alpha},c\alpha)$ is proportional to α for self-similar motion. Hence

$$V(r, \theta)=V(e^{\alpha}, \chi+c\alpha)=C\alpha+F(\chi) \tag{18}$$

where $\alpha=\ln r$ and $\chi=\theta-C\ln r$. That is,

$$V(r, \theta)=C\ln r+F(\theta-c\ln r) \tag{19}$$

This expresses the motion in terms of an arbitrary constant C and a function F of one variable, and is the analog of equation 6, although much more complicated.

As before, we now substitute in the general differential equation 15. The calculations follow. In general,

$$\nabla^2=\frac{1}{r^2}\left(\frac{\partial^2}{\partial\alpha^2}+\frac{\partial^2}{\partial\theta^2}\right) \text{ whence } \nabla^2 V=e^{-2\alpha}\,(c^2+1)F''.$$

Since

$$\partial/\partial(x, y)=r^{-2}\partial/\partial(\alpha, \theta)$$

we infer by substitution in equation 15

$$\frac{\nu}{r^2}\left[\left(\frac{\partial^2}{\partial\alpha^2}+\frac{\partial^2}{\partial\theta^2}\right)(e^{-2\alpha}(c^2+1)F''')\right]=\frac{1}{r^2}\left[\frac{\partial V}{\partial\alpha}\,\frac{\partial(\nabla^2V)}{\partial\theta}-\frac{\partial V}{\partial\theta}\,\frac{\partial(\nabla^2V)}{\partial\alpha}\right] \tag{20}$$

Carrying out the operations indicated, with $V=C\alpha+F$, we get

$$\nu[(c^2+1)F^{\mathrm{IV}}+4cF'''+4F'']=(C-cF')F'''+2F'F''+cF'F''' \tag{21}$$

This is the ordinary differential equation obtained by Oseen;[4] it would be difficult to find another equally simple motivation. Equation 21 can be made somewhat less repulsive through the substitution $G=F'$; also, it is satisfied whenever $F''=0$. In any case, it can be integrated numerically.

The two examples given could be multiplied almost endlessly; however, I think they give enough of a background to permit a general formulation of the method. For this formulation, the concept of a group is essential.

We first observe that the sets G of transformations 1, 5*a*, and 16 form *groups* in the following technical sense. If α and β both belong to G, then the resultant (usually written $\alpha\beta$) of performing α and β in succession, also belongs to G. (In case 1, it is given by

$$q''_i=\beta_i q'_i=\beta_i(\alpha_i q_i)=(\alpha_i\beta_i)q_i$$

while a similar more complicated formula holds for the Q_j.) So does the "inverse" of α, which is $q_i=\alpha_i^{-1}q'_i$ in case 1. The rotations of a sphere also form a group.

It might be supposed that dimensional analysis, based on the principle that "all systems of fundamental units are equally valid," alone had physical validity—whereas the mathematical concept of group involved purely metaphysical speculation. But this supposition is very erroneous. Thus the laws of electromagnetism are patently not the same in all units of length and time; the same is actually true in mechanics, at speeds comparable with that of light. Indeed, the point of special relativity is precisely that distance and time cannot in general be measured independently; and special relativity is an experimental fact.

The clearest distinction between (exact) relativistic mechanics and (approximate) Newtonian mechanics is perhaps the statement that the former is invariant under the Maxwell-Lorentz group, like electromagnetism, whereas the latter is invariant under the Galilei-Newton group, and so admits arbitrary changes of unit of length and time. Also, on a more elementary level, one actually uses the groups of rotations and translations of space at least as often as changes of units. Hence I see no reason why engineers should not welcome the word "group" into their vocabulary.

We next observe that the pi theorem is merely the simplest case of the following general geometrical principle. Let equation 3 be invariant under *any* r-parameter group G of transformations

$$Q'_j=f_j(\alpha_1, \ldots, \alpha_r; Q_1, \ldots, Q_m) \tag{22}$$

Then G circulates the points of s-dimensional subsets S_τ of m-dimensional $(Q_1, \ldots, Q_m)$ space, or Q space. In general, $1 \leq s \leq r$; a typical case is that of the 3-parameter group of rotations, which circulates the points on 2-dimensional spheres. (In general, the S_τ are called the "sets of transitivity" of G, and they have been exhaustively discussed in books on group theory.) By the implicit function theorem, we can so choose co-ordinates $(x_1, \ldots, x_s; x_{s+1}, \ldots, x_m)$ in Q space that the S_τ are defined by

$$x_j=c_j\ [j=s+1, \ldots, m]$$

Since G transforms each S_τ into itself, it follows that the $(m-s)$ functions

$$x_j(Q_1, \ldots, Q_m)\ j=(s+1, \ldots, m)$$

are invariant under G; hence they reduce in the case of equation 1 to dimensionless quantities. Now let M be the $(m-1)$-dimensional hypersurface defined by equation 3. Since it is invariant under G, it includes all or none of each S_τ. Hence it consists of an $(m-s-1)$-dimensional subfamily of the $(m-s)$-dimensional family of loci $x_j=c_j$; hence it is definable locally by

$$g(x_{s+1}, \ldots, x_m)=0 \tag{23}$$

where the functions $x_j(Q_1, \ldots, Q_m)$ involved are invariant under G.

The weak points of the generalization are

1. The theorem is now valid only locally, and not in the large. (The usual proofs of Buckingham's pi theorem are also valid only locally; it is only by requiring that the $\alpha_i>0$, that the theorem becomes valid in the large.)
2. No explicit procedure for computing the functions $x_j(Q_1, \ldots, Q_m)$ is proposed.

However, as illustrated by the preceding examples, in practical examples these functions are usually well known. Within these limitations, we may state the following.

Generalized Pi Theorem. Let $f(Q_1, \ldots, Q_m)=0$ be invariant under a group G which circulates the points of s-dimensional subsets S_τ. This equation is equivalent to an equation

$$g(x_{s+1}, \ldots, x_m)=0$$

between $(m-s)$ functions $x_j(Q_1, \ldots, Q_m)$, each of which is invariant under G. In fact, *any* $(m-s)$ functionally independent G-invariant functions of the Q_i will work. Thus the fact that local co-ordinates can be found under which the surface reduces to $X_m=0$ is of little value.

The situation with partial differential equations is naturally more complicated. We suppose given, not a relation like equation 3 between the Q_i alone, but an equation involving the Q_i and their partial derivatives. Here, in view of our vast ignorance concerning partial differential equations in general, we cannot hope for a neat universal theorem.

In the cases treated here, there was one dependent variable, and $(m-1)$ independent variables; we may denote these Q_1, and $Q_2, \ldots, Q_m$, respectively. Such a partial differential equation defines, instead of a single $(m-1)$-dimensional hypersurface, a whole class of such hypersurfaces.

The equation was known to be invariant under a group G of transformations (equation 22), and we looked for hypersurfaces which were also "G-invariant," or invariant under G.

In case G is equivalent (under change of co-ordinates) to a translation-group

$$x'_j=x_j+\beta_j \quad (j=s+1, \ldots, m)$$

we can get a neat result. It may be noted that this happens in ordinary dimensional analysis if the variables log Q_j are used; it was also the case with equation 5*a* and (using $\lambda=\ln r$ and θ) with equation 16. In this case, G-invariance means simply that the variables $x_{s+1}, \ldots, x_m$ are omitted from coefficients, and G-invariant solutions can be obtained in the form $x_1=\phi(x_2, \ldots, x_s)$, provided there are derivatives which do not involve $x_{s+2}, \ldots, x_m$.

Cases like spherical symmetry in the heat equation can be treated by the Cauchy-Kowalewski theorem, which asserts that if $U(x_1, \ldots, x_n, t)$ is given and analytic at $t=0$, then any analytic differential equation of the form

$$\frac{\partial U}{\partial t}=F(U, \partial U/\partial x_i, \partial^2 U/\partial x_i \partial x_j, \ldots)$$

defines a local extension of the given solution. If U is G-invariant at $t=0$, and F is G invariant, then the local extension will be G invariant.

In the general case, it seems necessary to rely on considerations of physical plausibility (which usually have anticipated mathematical theorems in the realm of partial differential equations) for existence and uniqueness theorems. At all events, whenever a differential equation is invariant under a group G of transformations, it is certainly a good gamble to try for solutions invariant under G or its subgroups—and whenever dimensional analysis yields nontrivial results, such a group is almost sure to exist.

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Lead-in-Air Detector

In the manufacture of various lead compounds, it is necessary to maintain a close check to make certain that toxic amounts of lead or compounds of lead have not escaped into the atmosphere. To avoid danger to the health of the workers, amounts of lead in the air must be kept at very low levels.

A new instrument, capable of detecting lead in concentrations below one part in seven million on a weight basis (the maximum safe concentration allowable), was described before a recent meeting of the Optical Society of America by Henry Aughey of the chemical department of E. I. du Pont de Nemours and Company.

With the device, determinations of lead content can be made instantly. Air from the area under investigation is drawn through a tube in such a way that it passes through an electric spark discharge, with the result that it admits light. All the light coming from the spark discharge is passed through a quartz spectrograph where it is broken up into its component parts, just as ordinary light is broken up into a spectrum by passing it through a glass prism.

In the original instrument, the band of light which resulted from the presence of lead was allowed to fall on a photographic plate, which was subsequently developed. The density of the resulting image was a measure of the amount of lead present in the air. In a later modification now employed, the band of light caused by the presence of lead in the air is passed into a photoelectric Geiger counter, specially manufactured by the North American Philips Company, similar to the device used for measuring radioactivity.

Through the use of the Geiger counter, a pulsating electric current is produced, the strength of which depends upon the intensity of light going into the photoelectric portion of the counter. The intensity of this light, in turn, depends upon the amount of lead in the air which was passed through the spark discharge.

With detection being made instantaneously and continuously, the lead in the air can be measured long before it reaches dangerous proportions. The device is far more sensitive, and faster, than all previously known chemical means.

Although the device has been tried only for lead so far, similar sensitivity in detection of other metals, both in elemental and combined forms, can be expected. It may be employed in all parts of plants that need air investigation since it is compact and mobile.

Shore Power from Naval Vessels

F. E. ANDERSON W. H. FIFER
FELLOW AIEE

DURING THE EARLY stages of the Normandy invasion in World War II, the French port of Cherbourg fell to the Allies. The city was virtually without electric power, however, because of damage to the generating equipment. The Allies rushed a destroyer escort, the *USS Donnell*, into the harbor. In a short time power from the vessel's generators was being supplied to Cherbourg.

Just prior to the Cherbourg incident, the Bureau of Ships had started a study of a-c electric-propelled ships to determine which would be most suitable to supply shore power. The turbine electric a-c destroyer escort vessels were found to be best suited. In order that these vessels might be used to supply shore power readily, equipment was designed to transmit the power from ship-to-shore, and included a variable ratio power transformer, switchgear, control and protective equipment, and high-voltage power cable.

This equipment first was installed on the *USS Wiseman*, at the Charleston naval shipyard, Charleston, S. C. Satisfactory tests were run feeding power into the South Carolina Power Company system. Identical installations then were made on the *USS Whitehurst* and *USS Marsh* by the Pearl Harbor naval shipyard.

PRACTICAL APPLICATIONS

Immediately after the capture of Manila by the United States forces, the *USS Wiseman* provided power to the city for several months. At the close of the war, the *Whitehurst* and *Marsh* supplied power for dredging at Guam. Later the *Marsh* provided power at Kwajalein during the "Crossroads" A-bomb tests.

The equipment as installed on these ships reduced military effectiveness and added undesirable topside weight. To avoid this, it was decided to mount the transformer and switchgear on a pier or barge alongside the vessel when required for emergency power. The *USS Foss* and *USS Maloy* supplied power under test in this manner at the New York naval shipyard in May 1946, and were held in readiness to supply power if an emergency arose because of the coal strike at that time. A serious drought in the fall of 1947, in New England drastically had reduced the hydroelectric power output, and an emergency condition arose in the processing of foodstuffs due to the power shortage. These two vessels satisfactorily supplied a load of about 9,000 kw for five months at Portland, Me.

There are several differences between the use of generators for propulsion and for shore power services:

1. The generators supply only one or two loads (propulsion motors) for propulsion service as compared with a large number of loads in shore service.
2. Constant volts per cycle regulation is used for propulsion service rather than the constant voltage of shore power.
3. No circuit breakers are used in propulsion service. Power is cut off by removing the generator field excitation.
4. Propulsion generators are not operated in parallel.

In order to use propulsion generators for shore power, the power-conversion equipment, referred to previously, was provided for the destroyer escort vessels. Control panels are provided for each of the vessel's two engine rooms, and contain the equipment to allow parallel operation of the two propulsion generators.

The power transformer is a 3-phase forced-oil-cooled unit with a variable voltage secondary. The unit is rated 4,500 kva at 60 cycles and 3,750 kva at 50 cycles. The primary voltages are 1,725 adjustable to 1,552 at 60 cycles, and 1,450 adjustable to 1,277 at 50 cycles. The secondary voltages are 7,200 and 21,600 delta and 12,500 and 37,500 Y. A tertiary winding provides voltages of 2,400 delta and 4,160 Y, but the power output is reduced to 1,667 kva.

The switchgear consists of two triple-pole circuit breakers rated 5,000 volts, 1,200 amperes, with 100,000-ampere interrupting capacity. Each circuit breaker enables its associated generator to be removed from the line. Phase balance, ground, overload, and reverse power relays are provided for tripping the circuit breaker in case of a fault. The power transformer and switchgear with the required auxiliaries are assembled together to form a unit substation of the outdoor type.

Special high-voltage submersible cables are provided for connecting the transformer secondary with shore when the power line must be carried over water, and cellular rubber floats float the cable ashore. Special motor-driven cable reels are provided to handle 1,000-foot lengths of the cable.

It is practical to use propulsion generators on naval vessels to supply emergency shore power. However, the primary mission of a naval vessel is as a fighting ship and all equipment is designed to perform most efficiently in this function. The rated frequencies and voltages are likely to be different from those used for shore power. As a result, the full power of the unit may not be used when supplying shore power. Considerable auxiliary equipment will be required also.

Not all large naval vessels can supply large amounts of shore power. The turbine-electric a-c destroyer escort vessels are the only ones which might be available for supplying 60-cycle shore power. The power output from one of these vessels is only 4,500 kva. The majority of these vessels are in the reserve fleet, and their reactivation for shore power use is not warranted except in extreme emergency conditions.

Digest of paper **48-231**, "Use of Propulsion Generators on Naval Vessels to Supply Shore Power," recommended by the AIEE marine transportation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Bolted Aluminum-to-Copper Connections

W. F. BONWITT

THE INCREASED use of aluminum as an electric conductor has raised the problem of suitable connectors, especially when connections have to be made between aluminum and copper. Since aluminum-to-aluminum connections offer no serious problems which have not been satisfactorily solved in one way or another, this investigation has been confined to the electrical performance of aluminum-to-copper connections. The purpose of conducting this rather extensive investigation was to determine the feasibility of making direct connections between aluminum and copper, to determine the most suitable finish (plating) for the copper member of the connection (the aluminum member was always bare), and to determine the effect of using a compound in such connections. Although aluminum has been used for many years for the purpose of conducting electric current (mainly for overhead transmission in the form of ACSR, and to some extent for busbars), only very limited information and experience is available in respect to the electrical performance of bolted (clamped) connections made between aluminum and copper.

It is easy to understand that the ideal solution would be a universal connector, which will work equally well with copper and aluminum. This has been recognized for a long time and many attempts have been made to provide such a connector. At present, several copper, or copper alloy, connectors are being offered for use with aluminum conductors. All these connectors have a finish (plating) on the copper base metal, and in addition some of the manufacturers specify the use of a compound in making these connections between the aluminum conductor and the connector.

Since the practical experience with these connectors is as yet limited, it was found desirable to determine the most suitable finish or plating for the copper member of the connections, and the effect of different compounds on the electrical quality of these connections. Extensive tests have been made using bolted connections between bare aluminum and copper bars. Various electro- and other platings were applied to the copper members of these connections, and all variations were tested further with and without compounds between the contact surfaces. Altogether, 21 combinations thus were observed under two separate test conditions: elevated temperatures, and corrosive atmosphere.

Identical but separate samples were used for both test procedures, and all samples were observed during a natural aging period of 624 hours, or 26 days, after assembly before undergoing any one of the two test procedures.

Digest of paper 48-216, "An Experimental Investigation of the Electrical Performance of Bolted Aluminum-to-Copper Connections," recommended by the AIEE transmission, distribution, and substation committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Elevated temperatures up to 200 degrees centigrade (392 degrees Fahrenheit) were applied in steps of 25 degrees centigrade (45 degrees Fahrenheit) for periods of eight hours each. The corrosive atmosphere was obtained from a 20 per cent aqueous sodium chloride solution atomized by preheated, saturated air under 15 pounds per square inch pressure, and maintained at a temperature of 35 degrees centigrade (95 degrees Fahrenheit). Samples were exposed to this atmosphere for 1,000 hours. The main criterion of performance was the electrical resistance of the aluminum-to-copper connections. These resistances were recorded after assembly, after a natural aging period, and were measured frequently during the test procedures.

It was found that a properly made bolted connection between aluminum and copper conductors will be completely satisfactory in electrical respect under the severe conditions applied. The most important precaution which has to be taken to insure a low-resistance, stable connection, is the use of a compound such as Penetrox "A". If such a compound is applied to the contact surfaces before bolting the members together, the kind of protective metallic coating (plate) becomes of secondary importance.

If, however, no compound is applied, the plating of the copper member becomes the determining factor for the performance of the connection, with tin plate preferable to any other plate. Also, the tin plate is particularly effective in flowed form (the flowing process converts the crystalline structure of the electroplate into an amorphous state). Although the use of a compound is recommended strongly, the performance of a connection between the bare aluminum and copper, protected by flowed tin, will be satisfactory even if no such compound is used.

The following conclusions are based on the results given previously and also on the visual examination of the test samples:

1. The samples using tin as a finish for the copper member of the connections stood up better than samples with any of the other metals used and were also superior to bare copper samples.

2. Within the sample groups using tin, the group with a flowed-tin finish was the best.

3. The use of a compound between the contact surfaces will have a much greater effect on the level of the contact resistance and its stability than the finish on the metal.

4. Flowed tin was the only finish tested which produced satisfactory contact conditions throughout the test even when used without a compound.

5. Appearance of corroded samples and especially of their contact surfaces is misleading. A clean, bright surface does not necessarily indicate good electric contact conditions (low-contact resistance).

6. The potential difference between two metals forming an electric connection or their relative standing in the galvanic series should not be over-estimated. In the presence of a compound or possibly even a lubricant only, the performance of the bare copper aluminum samples was surprisingly good.

Rural Distribution Voltages

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Tests on suggested voltages for rural electrification have been made by the Rural Electrificational Administration. Their findings will be tried out in the near future on two projects, one in New Mexico and the other in Arizona.

AT THE TIME the Rural Electrification Administration was established by executive order in May 1935, the voltages on rural distribution systems covered a wide range and included some of the multigrounded Y systems that are in use today. Single bushing 6,900-, 7,200-, and 7,620-volt transformers had been made available by the manufacturers.

The REA made an extensive study of the voltages that were then in use, and in December 1936, issued suggested specifications for 12,000/6,900-volt Y-multigrounded neutral-distribution circuits. This selection was based largely upon Tennessee Valley Authority practice and the fact that transformers were available. Within a short time the REA's suggestions were changed to the present 12,470/7,200-volt Y-multigrounded neutral specifications.

After lines had been constructed to serve a definite area, there was a great demand for service outside that area with the result that many additions were made which had to be served over the original lines or modifications of them.

The earlier REA-financed systems had consumptions on the order of an average of 50 kilowatt-hours per month per consumer. Up until the last few years most lines were designed on the basis of approximately 100 kilowatt-hours per month per consumer. However, the consumption per consumer has been steadily increasing until now consumptions of 300 and 400 kilowatt-hours per month per consumer are not unusual, and the end is not yet.

The system operators have had to meet this load growth by installing voltage regulators, increasing the number of phases and increasing the size of conductor. There is a limit to the number of regulators that can be cascaded and the amount of rephasing that can be done. There is also an economic limit to increasing the size of conductor. Increasing the size of conductor reduces the resistance, but reduces the inductance only a little. For lines with reduced size neutral, the curve of admittance plotted against pounds of conductor begins to flatten out above No. 2-copper conductivity-phase wire. With some conductors, the cost per mho for 4/0 conductor is more than double that of number 6.

There is an increasing demand for service in sparsely settled areas where the distances to be covered are much greater than on systems heretofore constructed. More than usual economy is required to construct these systems.

Full text of paper **48-241,** "Rural Distribution Voltages," recommended by the AIEE transmission and distribution committee and approved by the AIEE technical program committee for presentation at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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It appears that some departure from the present standard distribution voltage is required. As early as 1937, the REA considered the possibility of using 22,300/13,200 volts as another multigrounded-Y-voltage standard, and the idea of using this or a slightly higher voltage has come up from time to time.

The load capacity of a distribution system varies as the square of the system voltage. A 23.9/13.8-kv Y-connected multigrounded system would have 3.67 times the capacity of a 12.47/7.2-kv system using conductors of the same size. A uniformly loaded line at 23.9/13.8 kv may be extended 90 per cent further and serve 3.67 times the area of a uniformly loaded line at 12.47/7.2 kv with the same size conductors. This takes into account the loads on the additional 90 per cent of line.

About 1942 a co-operative in Minnesota purchased approximately 50 miles of 23.9/13.8-kv Y-connected multigrounded transmission line with some 13.8-kv transformers (15-kv insulation class) installed along the line. Most of these transformers had been installed in 1916. After the acquisition of this line, the co-operative began buying transformers to be used on extensions to serve farmers and in 1944, there were some 150 or 160 13.8-kv transformers (15-kv insulation class without lightning arresters) connected on this line. The manager stated in 1944 that in the two years the co-operative operated the line, not a single transformer had been lost due to lightning, and that the operating experience with the transformers had been excellent. An REA field construction engineer reported on this line in April 1947 and from what he could learn, no more 13.8-kv transformer failures occur than with the 7.2-kv transformers on other parts of the co-operative's system. Some of the 23.9/13.8-kv line has been absorbed into the 12.47/7.2-kv portion of the co-operative's system so that there are now 80 miles of 23.9/13.8-kv line with 70 transformers.

The estimated costs of two proposed projects in Colorado were as follows:

	Project A	Project B
Primary miles	387	208
Consumers	434	238
Cost using 12.47/7.2 kv	$702,672	—
Cost with transmission line and substations added	$559,756	$625,000
*Cost with 23.9/13.8-kv distribution	$475,565	$415,000
Per cent saving 23.9/13.8 kv over 12.47/7.2 kv plus transmission	15 per cent	34 per cent

* 15 kv insulation class transformers with the same lightning arresters as if the transformers were connected in delta.

Increasing the distribution voltage to 23.9/13.8 kv does not materially effect conductor separation although it would

decrease the maximum allowable span length to a small extent. Apparently the National Electrical Safety Code permits the same ground clearance for single-phase sections of 23.9/13.8-kv systems as on present systems but, however, an additional 2-foot ground clearance is required on multi-phase sections of 23.9/13.8-kv systems.

No REA-financed systems have been completed as yet using 23.9/13.8-kv distribution. The transformer manufacturers do not recommend nor guarantee their 15-kv insulation-class transformers for this service. Their objections are based mainly on these two points:

1. On a 13,800-volt 15-kv insulation-class transformer the insulation between the winding and the case was designed for the electrostatic voltage of 7,968 volts. The phase voltage of 13,800 would occur only between the winding and case under faulted conditions. When this transformer is connected between a phase wire and ground on a 23.9/13.8-kv Y-connected system, the voltage between the winding and case always would be 13,800 volts.

2. On a 13,800-volt 15-kv insulation-class transformer connected between a phase wire and ground on a 23.9/13.8-kv Y-connected system, a fault to ground on one phase would cause an excessive voltage rise on the other phases which would damage the transformers.

The effect of line-to-ground faults on the voltage of the unfaulted phases was calculated by the methods given in chapter 15 of the "Electrical Transmission and Distribution Reference Book." The calculations were only for the substation and the distribution line without the transformers. According to these calculations, the voltage rise for 6A conductor with the fault at a considerable distance from the substation was approximately 58 per cent. It is realized that the calculations were for lines which are not comparable to distribution lines built to REA specifications, but it is likely that calculations of this kind have tended to create the impression that the effect of the neutral shift is greater than is actually the case.

In order to determine the voltage rise due to the neutral shift, it was decided to place line-to-ground faults on one phase and measure the voltage on the unfaulted phases on an existing system in an area of high ground resistivity. The system selected for the tests was that of the Southside Electric Cooperative, in the vicinity of Blackstone, Va.

A 50-ampere oil-circuit recloser with the current coil short-circuited out was used in making the line-to-ground faults. A type *PM 13* 6-element oscillograph was used to record the voltage on the unfaulted phases and the fault current. Ground resistances were measured with a model 251 Vibroground.

The oil-circuit breaker was connected between a phase wire and the neutral which was connected to a ground rod. A current transformer was placed in the lead from the oil-circuit breaker to the neutral. Potential transformers were connected between phase wires and neutral. The fault-current reading was obtained where the fault and oscillograph were in the same location but in some instances it was too large to get a reading.

The first series of tests was made on lines feeding from a 66/12.47/7.2-kv 5,000-kva substation. In these tests the resistance of the neutral-to-ground ranged from 22 to 24 ohms at the location of the tests. Oil-circuit reclosers in the distribution circuits limited the duration of the faults.

In test *A*, the fault was made at a distance of 11.9 miles from the substation. This mileage consisted of 5.9 miles of 3-phase 1/0-copper-phase wires with 6A neutral and 6.0 miles of 3-phase 4A-phase wires with 6A neutral. The recorded voltage rise on the unfaulted phases at the location of the fault was 14 and 18 per cent and lasted a maximum of 15 cycles.

In test *B*, the fault was made at a distance of 26.1 miles from the substation. This mileage consisted of 5.9 miles of 3-phase, 1/0-copper-phase wires with 6A neutral, 9.6 miles of 3-phase, 4A-phase wires with 6A neutral and 10.6 miles of V-phase 6A-phase wires with 6A neutral. The fault current was 120 amperes, and the recorded voltage rise on the unfaulted phase at the location of the fault was 23.5 per cent and lasted a maximum of 38 cycles.

In test *C*, the fault was made on a single-phase tap at a distance of 22.1 miles from the substation. This mileage consisted of 5.9 miles of 3-phase 1/0-copper-phase wires with 6A neutral, 9.6 miles of 3-phase 4A-phase wires with 6A neutral and 6.6 miles of 1-phase 6A-phase wire and 6A neutral. The recorded voltage rise on the unfaulted phases at a point 10.6 miles on the V-phase 6A-phase wires with 6A neutral line beyond where the 1-phase tap left the main line, was 7 and 20 per cent respectively, which lasted a maximum of 7 cycles.

In test *D*, the fault was made at a distance of 11.9 miles from the substation. This mileage consisted of 5.9 miles of 3-phase 1/0-copper-phase wires with 6A neutral and 6.0 miles of 3-phase 4A-phase wires with 6A neutral. The voltage was recorded at a point beyond the fault and at a distance of 26.1 miles from the substation. The line beyond the fault to the point where the voltage was recorded consisted of 9.6 miles of 3-phase 4A-phase wires with 6A neutral and 10.6 miles of V-phase 6A-phase wires with 6A neutral. The recorded voltage rise was 12.5 and 30 per cent respectively, and lasted a maximum of 18 cycles.

The second series of tests was made in an area about 90 miles from the first series of tests on lines feeding from a 13.2/12.47/7.2-kv 600-kva substation. In these tests the resistance of the neutral-to-ground was 25 ohms at the location of the tests.

In test *E*, the fault was made at a distance of 12 miles from the substation. This mileage consisted of 3-phase 6A-phase wires with 6A neutral. The fault current was 86 amperes, and the recorded voltage rise on the unfaulted phases at the location of the fault was zero per cent on both phases. Actually, a slight decrease in voltage was shown.

In test *F*, the fault was at a distance of 20 miles from the substation. This mileage consisted of 18 miles of 3-phase 6A-phase wires with 6A neutral and two miles of V-phase 6A-phase wires with 6A neutral. The voltage was recorded at a point 12 miles from the substation on the 3-phase section of the line. The voltage rise on the unfaulted phase was zero per cent. Actually, a slight decrease in voltage was shown.

In the first series of tests the voltage rise on the unfaulted phases, due to a line-to-ground fault, ranged from seven per cent to a maximum of 30 per cent. The effect of the fault current on the regulation on the 66-kv line supplying the delta connected, 5,000-kva substation was probably negli-

gible so that practically the full effect of the neutral shift was apparent. Also, the voltage drop across the impedance (IZ drop) in the neutral was larger than would have been the case had the neutral been the same size as the phase conductors.

In the second series of tests there was no voltage rise on the unfaulted conductor due to a line-to-ground fault. This probably can be explained by the fact that the power is supplied to the delta-connected 600-kva substation over a 13,200-volt line and that the regulation, due to the fault current, cancels out the voltage rise produced by the neutral shift. Also, the IZ drop in the neutral was not as large as would have been the case had the neutral been of less size than the phase conductors.

The foregoing tests were made in areas of comparatively high-ground resistance. These tests did not show as much neutral shift as had been calculated for bare lines without taking into account the constants of the system supplying power to the co-operative's substation.

Weighing the need in some areas for a considerably higher distribution voltage that would be economical against the possible hazards of equipment failure, it has been decided that some construction at a distribution voltage of 23.9/13.8 kv is warranted at this time. Two projects now have been approved for this type of construction, one in Arizona and one in New Mexico.

The Arizona project will consist of 284 miles of distribution line to serve 365 consumers. The distribution voltage is 23.9/13.8 kv. The first section, 125 miles to serve 174 consumers, is under construction. The area farthest from the source of power is at a distance of 70 miles. The distribution transformers to be used on this system are 13,800-volt transformers of the 15-kv insulation class.

The project in New Mexico will consist of 166 miles of distribution line to serve 248 consumers. The farthest extremity of the project from the substation is 76 miles. Consideration is being given to a new distribution-transformer design which will have insulation somewhat higher than the 15-kv class.

The performance of the two types of transformers will be watched closely after construction is completed, and tests made to determine which is the more satisfactory.

A higher distribution voltage for use in rural areas is definitely needed where farms are widely separated and kilowatt-hour consumption will be substantial. Use of the 23.9/13.8-kv system is, of course, nothing new, but in order that construction costs be within limits of feasibility, a substitute for the presently available 25-kv-class distribution transformer must be found. A voltage rise of 30 per cent during a line-to-ground fault, lasting 18 cycles, does not appear excessive, and it is believed worthwhile to install 15-kv class transformers on an experimental basis.

Analyzing Television Lenses and Tubes

A new method, using what is essentially a television pickup and reproduction system to provide the first practical means of analyzing and rating the ability of lenses, television camera tubes, and television picture tubes to show picture detail, was outlined by Otto H. Schade, advanced development engineer of the tube department of the Radio Corporation of America, before the Institute of Radio Engineers and the Radio Manufacturers Association at their fall meeting in Rochester, N. Y. The talk was entitled "A Discussion of Image Sharpness in Photography and Television." The theoretical values by which lenses have been rated heretofore, Mr. Schade explained, are based on their limiting or highest power of resolution, that is, the greatest number of lines of picture detail per millimeter which they can focus on film or viewing screen.

However, useful resolutions for photography and television are limited, respectively, by the response of photographic film and the width of television frequency channels. To improve picture detail within these limitations, the research engineer in these fields must strive for sharper contrast of light and dark picture elements within lower ranges of resolution—about 50 lines per millimeter in photography, and one-fifth as many lines in television. The system affords the first practical means of determining the contrast response of lenses in these ranges, or in any specified range from zero to the limiting resolution.

The equipment chain employed in the system consists essentially of a specimen mount, a lens mount, a microscope, a television camera, a television picture tube or kinescope, and an oscilloscope, arranged in that order. A test pattern made up of a series of vertical and horizontal lines of diminishing size and spacing is mounted before the lens to be tested or rated, and a greatly reduced image of the pattern is produced. The microscope enlarges this image before it is picked up by the television camera, providing a large, easily studied televised image on the kinescope, and a large, accurate "trace" or wave-form image on the oscilloscope. The latter image is formed by feeding a portion of the electrical signal from the television camera to the oscilloscope. Using this trace or wave-form as a basis, Mr. Schade has worked out a system for plotting curves on a chart to show the contrast or detail response of a given lens at any degree of resolution. Similar ratings for the electrostatic or electromagnetic lenses used in television camera tubes can be charted by an application of the same principle, while ratings for similar lenses in kinescopes are established by a modification of the system employing RCA's "flying spot" scanning tube to analyze the kinescope image.

The trace on the oscilloscope can be calibrated quickly, easily, and accurately by focusing on the photo surface of the television pickup tube a measured amount of light sufficient to cancel one of the dark lines in the kinescope image. This is done by mounting a small mirror at an angle to superimpose the light slit image on the test pattern image, and by using a phototube to measure the amount of light required for cancellation.

A simple method is also provided for finding the overall response of systems in which several imaging processes occur.

Conference Papers Digested for Middle Eastern District Meeting

These are authors' digests of most of the conference papers presented at the AIEE Middle Eastern District meeting, Washington, D. C., October 5–7, 1948. The papers are not scheduled for publication in AIEE PROCEEDINGS or AIEE TRANSACTIONS.

Electrical Requirements for Naval Aircraft; *A. H. Bergeson (Captain, United States Navy, Bureau of Aeronautics, Washington, D. C.).*

Naval aircraft are designed specifically to accomplish certain definite missions. To accomplish these missions the aircraft and all its components must be a carefully integrated design.

Electric systems are of major importance in the functioning of naval aircraft. They must be as completely reliable as human ingenuity can make them. Electronic components upon which the modern airplane depend so heavily, in turn depend upon the electric systems. If the electric systems fail, the airplane either stops flying or is seriously disabled.

Requirements for electric power in modern aircraft have risen rapidly to the point where it is now a serious problem for the electrical engineers to solve. In addition to the large demands for electric power, the system and its components must stand up under severe conditions of shock, vibration, and be resistant to all kinds of climatic conditions. They must be able to operate in extremely high altitudes, over great temperature ranges, be resistant to salt spray, high humidity, and be fungusproof.

Not so long ago, generator capacities of 75 amperes were ample for most of the Navy's aircraft. Today this capacity falls far short of Navy requirements. Five-hundred-ampere generators are now under development and yet these still fall short of forseeable requirements. Low-voltage direct current is hard to generate in large quantities in the space limitations available on the engine. Excessive cable weight is required for distribution of this energy. To alleviate this situation the major portion of the Navy's aircraft electrical development work is now concentrated on high-voltage systems. These include both direct current and 115–200-volt 400-cycle alternating current. In anticipation of still larger electric loads, 90-kva alternators are under development.

There are three basic problems in engineering of aircraft electric systems. First is the generation of the proper type and amount of electric power. The second is control and distribution of this power throughout the airplane. The third is the utilization equipment which must work, must be simple to maintain, and, again, must be small and light.

The solution of these problems will require the finest engineering ability of industry. They must be solved to meet the ever-expanding needs of modern aerial warfare.

Safety in Aircraft High-Voltage Electric Systems; *Morton H. Adolphe (Lockheed Aircraft Corporation, Burbank, Calif.).*

The acceptance in aeronautical electrical design of the so-called higher voltages of 120 volts direct current and 120–208 volts 3-phase alternating current elevates this problem of electrical safety to one of immediate importance in contemporary design. A recent survey shows that in one large aircraft manufacturing organization, two electric shock accidents requiring medical attention already have occurred to manufacturing personnel presumably familiar with this new 3-phase alternating current system and trained for the job.

The conditions under which serious electric shock can be experienced must be known generally to be avoided; 120 volts can be dangerous. It can and has been fatal. The physiological reaction to 400-cycle current is very closely the same as to 60-cycle current. Shock currents of 100 milliamperes alternating current generally will cause death by producing a heart condition known as ventricular fibrillation, wherein an aperiodic flutter of the heart muscles is substituted for the normal heart beat. Currents in amperes generally cause muscular paralysis, unconsciousness, loss of respiration, burns, or damage to vital tissues. A victim of such condition usually responds to artificial respiration and other medical aids, whereas no known treatment exists for ventricular fibrillation. A generally accepted value of nine milliamperes of shock current through the body is the largest current which the shock victim can let go. Much above this is dangerous. With an internal body resistance of not more than 1,000 ohms, the limitation of shock current to safe values is almost entirely due to contact resistance. This can be effectively zero where the area contacted is wet, sweaty, and dirty. Severe shock is then a definite possibility to aircraft personnel. The shock hazard from the 3-phase a-c system is considerably greater than that of the 120-volt d-c system. This results from two factors: The 3-phase system has much higher voltage available (208 volts line to line); and the effect on the body of direct current is much less than alternating current in the frequency range considered. A safe value of let-go current for direct current is taken to be about 60 milliamperes, about seven times larger than that for alternating current.

Aircraft personnel must be made aware of other inherent accident conditions. The likelihood of insulation failures from frayed wires is important. The interruption of currents at high voltage, particularly on d-c circuits, by the cutting of wires, removal of wires from terminals, or the use of temporary jumpers with the circuits under load can cause severe arcs.

Engineering design must consider the possibility of service personnel installing in high-voltage circuits, particularly direct current, familiar items of equipment customarily used on the more usual 28-volt d-c circuits. The use of such equipment unapproved for high voltage can result in severe arcing and explosion with obvious dangers of fire and injury to personnel. The designer should insist upon installing high-voltage equipment such as switches, contactors, fuses, and relays in such a manner that similar forms of unapproved equipment will not fit the installation, to make it evident to service personnel that such equipment must not be used.

It is expected that some engineering quarters will maintain their present aloofness from shop safety problems. In the author's opinion, the novelty of the present high-voltage systems combined with the general unfamiliarity of all aircraft mechanics (and a great many electricians too) require not only the designer but his entire engineering department to assume this responsibility, at least until such time as manufacturing personnel and operating personnel of the air lines and armed services become thoroughly familiar with all aspects of the problem.

Directional Effects in Dielectric Properties of Molded Rubber; *Arnold H. Scott (National Bureau of Standards, Washington, D. C.).*

Because of erratic results in dielectric measurements of some rubber-filler mixtures, a study was made of the effect of flow in molding on the electrical properties of these mixtures. Slabs of the material were prepared in such a way that flow in molding was accentuated greatly in one direction. These slabs then were cut into strips with square cross sections. For the electrical measurements the strips were assembled side by side between the plates of a guard ring capacitor so that an air gap was left between the sample and the upper electrode. After the dielectric constant and loss tangent were determined for the strips reassembled in their original positions, the strips were turned through 90 degrees so that the field was at right angles in the second case to that in the first case. By properly cutting the strips the dielectric constant and loss tangent could be obtained with the electric field in the three mutually perpendicular directions.

The dielectric constant and loss tangent obtained by means of spaced electrodes as described in the foregoing were found to be functions of the air gap between the specimen and the upper electrode. When the dielectric constant and loss tangent were plotted against the magnitude of the air gap, a curve was obtained which, when extrapolated to zero air gap, gave a value which was in fair agreement with the values obtained on the slab specimen using tinfoil electrodes. The extrapolated values therefore were used as the correct values for the dielectric constant and loss tangent of the mixture.

It was found that for gum rubber and for rubber-calcium carbonate mixtures there was little difference in the three directions. For all other samples the dielectric constant and loss tangent were greater in the direction of flow than in the direction perpendicular

to the original surface of the slab. A series of rubber-zinc oxide mixtures was studied and it was found that the behavior could be explained by assuming that agglomerates of the filler were formed and that these were flattened out in molding to make somewhat elongated ellipsoids.

Linear thermal expansivity of some of the rubber filler mixtures was determined by using cubes of the material under study as spacers for the optically flat plates of an optical interferometer. By counting the fringes that passed the cross hair as the temperatures changed, the expansivity was determined. It was found that for rubber-zinc oxide and rubber-lead oxide the expansivity was greatest in the direction perpendicular to the original surface of the slab. This was the direction of the minimum dielectric constant and loss tangent. Gum rubber and rubber titanium dioxide showed no directional effects as regards expansivity.

Atmospheric Transmissometry; *C. A. Douglas (National Bureau of Standards, Washington, D. C.).*

The problem of how far one can see is of prime importance to the pilot landing an airplane in foggy weather. During military operations the problem of how far one can be seen is often of even greater importance. The distance at which objects or lights can be seen as a function of atmospheric transmissivity has been the subject of numerous investigations. To apply the results of these studies in determining the visual range, a measurement of the transmissivity of the atmosphere is required. In field tests of the airport lighting systems now being developed for all-weather flying, a minute-by-minute record of the fog density at several locations on the airport is required. The National Bureau of Standards has developed an atmospheric transmissometer which will provide an automatic continuous record of the transmittance between two fixed points over a range of 10. The instrument consists of a projector source, a photoelectric receiver giving an indication in the form of pulses with the frequency proportional to the photoelectric current, and a remote indicator which makes it practicable to locate the indicator at a distance from the location at which the measurements are made.

Modulated Light Sources; *W. S. Huxford (Northwestern University, Evanston, Ill.).*

The most familiar examples of the use of light beams for transmission of signals are found in industrial control systems, traffic regulating devices, and movie-tone recording sets. During the war years many methods of great diversity were developed for transmitting intelligence on a beam of light. Such methods involve a variation in flux, in polarization, or in wave length (frequency modulation) of the radiation. The methods discussed in this paper are those in which the intensity in the beam cross section, or the total light flux, is modulated by mechanical, or mechano-optical methods; or by electrical modulation of the source itself.

Methods by which the properties of a beam of light emitted by a steadily burning source can be modulated are illustrated by several foreign and domestic communication units developed during the war. The Japanese photophones using vibrating mirrors are rugged units of simple design, but are not very efficient. The German Lichtsprechers represent mechanical and optical beam modulating principles incorporated in semipermanent installations having excellent design characteristics. Several portable units were developed in the United States for use by ground troops.

Electrical modulation of gas discharge sources has been widely exploited in military communication systems developed in recent years. The types of discharges employed include carbon arcs, the concentrated arc, and vapor arcs in mercury, cesium, and other substances. The results of measurements of the modulation efficiency of several sources are presented, and excitation processes in these sources and their spectral characteristics are discussed. Voice and code signaling units of efficient design for use on ships and aircraft are now available for line-of-sight communication. They serve as convenient auxiliary channels for voice, code, or other types of communication, or as main contact channels when radio or radar transmission cannot be used.

Survey of Radiation Measurement Methods; *G. Wesley Dunlap (General Electric Company, Schenectady, N. Y.).*

Radiation measurements are concerned chiefly with the detection and evaluation of alpha, beta, gamma, or neutron radiations. These are detected by the ionization produced in a medium either directly or indirectly by the absorption of energy from the radiation.

The ionizing ability of a radiation may be observed by means of a cloud chamber which shows up the actual ions left in the path of an individual particle.

Quantitative measurements are made by arranging an ionization chamber to collect the ions produced. The accumulated charge is measured by a physical or electronic electrometer. A wide range of radiation intensities may be covered with ionization chambers and appropriate auxiliary circuits.

To increase the sensitivity of detection, use is made of the Geiger counter. This is an extension of the ionization chamber principle by the utilization of gas amplification and single particles may be detected. It is perhaps the best known device and is used widely for measurements in the lower ranges of radiation intensity.

An intermediate device is the proportional counter which provides a compromise between ultimate sensitivity and proportionality with the initial ionization.

Extension of the detection technique to utilize ionization or energy absorption in media other than gases provides additional methods. These include the following.

The crystal counter depends on the detection in certain crystals of the motion of electrons freed by radiation.

The photomultiplier counter or scintillation counter depends on the detection of light radiation from a phosphor under the influence of radiation.

The photographic emulsion method depends on the activation of the emulsion by energy absorbed from radiation and the developed film may be analyzed to indicate integrated exposure or to show tracks of single particles.

Use of Power in Military Floating Dry Docks of the United States Navy; *W. W. Newlund (Navy Department, Bureau of Yards and Docks, Washington, D. C.).*

In World War II we saw, for the first time in history, long sustained fleet operations carried on far from established fleet bases. Such long sustained operations could not have been carried on as they were had it not been for the support supplied by the military floating dry docks.

In earlier days a fighting ship that was so damaged as to require dry-docking had to go (even as Mahomet went to the mountain because the mountain would not come to him) to a repair base—if it could get there. Now our Navy has gone Mahomet one better and brought the repair bases to the ships. An important arm of the mobile or floating repair base is the military floating dry dock, which enables major hull repairs, that formerly could not be accomplished by repair ships alone, to be made close to the scene of action. Thus many ships that, in a previous war, would have been knocked out completely or at least incapacitated for many months, in World War II quickly were restored to fighting trim. Aside from enabling major hull repairs to be made, these docks contributed to maintaining the ships speed at a maximum by permitting routine bottom scraping—for removal of barnacles—to be done at frequent intervals.

This article is a brief nontechnical description of the military floating dry dock, what it is and what makes it tick, how it differs from the "commercial" floating dry dock, its mission, the diversity of power consumption, and the size and type of power plant.

Multipoint Networks for Telephone and Telephotograph Services; *Eldon Nichols (American Telephone and Telegraph Company, New York, N. Y.).*

The success of many modern enterprises depends upon the ability of people dispersed over a large area to exchange information almost instantly and to act together as members of a single team. Hundreds of aircraft quickly are moved from the path of a hurricane to the safety of distant fields where people already have made preparations to receive them. A pipe line carries fuel oil for one distant city, followed immediately by gasoline for another. These are but two examples of many situations in which the close co-ordination of widely separated people is obtained by the use of specially engineered communications systems.

One of these systems which is finding a wide field of application is a multipoint network resembling a "party" telephone line but spreading over a large area and containing thousands of miles of line facilities. While many of these networks are used exclusively for telephonic communication, a considerable number have additional design features to permit the transmission of pictures, weather maps, or other facsimile material as well as speech.

The larger services often are designed in the form of several separate networks which the customer can combine into a single network at will by means of switching devices. A dial system is available which permits each station to operate a bell or lamp signal in any other station and, if

desired, several or all of the other stations may be signaled simultaneously by dialing a special number. The dial pulses are sent over the telephone facilities in the form of voice-frequency tones.

Echo effects caused by the reflection of speech currents back from impedance irregularities at distant terminals are more serious than on ordinary 2-point long-distance circuits. This is because of the larger number of echo paths and the higher volume levels required at noisy locations such as air fields and pumping stations. Measures to reduce these echoes to acceptable values include careful design of bridging, balancing, and terminating networks, the use of high-velocity line facilities, and the provision of echo suppressors. In the larger networks it is also necessary to use "4-wire" telephones in which the transmitter and receiver are connected to two separate channels to the central office.

Picture and facsimile transmission may be affected seriously by delay distortion, level changes, or other effects too minute to be heard or noticed in a telephone conversation. To minimize level changes, temperature compensating devices which operate in discrete steps are blocked automatically during actual transmission periods and amplifiers are equipped with negative feedback circuits to reduce the effects of variations in supply voltages. Delay distortion is controlled by providing specially designed delay equalizers and the delay-frequency characteristics of the over-all network are checked with a measuring set having an accuracy of about ten microseconds.

A typical New York-San Francisco circuit without branches or side legs contains approximately 1,200 vacuum tubes and 200,000 soldered connections. Such complexity makes it necessary to exercise care in the design and installation of equipment and in the establishment of maintenance procedures in order to minimize service interruptions. Where practicable, patching jacks and switching relays have two pairs of contacts in parallel, each pair consisting of two wiping bars of special alloys. Equipment and wiring are closely inspected before being placed in service. Vacuum tubes are tested at specified intervals and are replaced if they fail to meet rigid requirements. These and numerous other precautions have permitted the furnishing of generally satisfactory service.

The rapid and continuing increase in multipoint networks indicates that they are meeting successfully a real need in the field of long distance communications.

Lockheed Constitution Electrical Test Program; *Henry Rempt* (*Lockheed Aircraft Corporation, Burbank, Calif.*).

The *Constitution* electric system originally was chosen to be 400 cycle, 208 volt, 3-phase, alternating current. The main reason for the choice of high voltage was the weight saving over the 24-volt system. This saving amounted to approximately 850 pounds. As the Navy had no high-voltage program, it was decided that the choice and testing of the electric system would be the responsibility of the Lockheed Aircraft Corporation. It was realized that the a-c program was new to the Lockheed Corporation and that in order not to jeopardize the flight-test program, all the electrical bugs must be worked out before the engines were run.

Also, it was realized that the great benefit of a complete mockup of mechanical parts definitely had been proved in the *Constellation* development program. Prior to first flight of the *Constellation*, the mechanical and hydraulic systems were all completely laboratory-tested, including a 500-hour simulated operational test. As a result, the *Constellation* made six takeoffs and landings on its first day of flight and no mechanical problems developed to interfere with the first day's important aerodynamic flight test program. A similar program had been planned for the mechanical systems of the *Constitution*, and because of the increase in the number and importance of the electric systems and functions, the same type program was indicated for the *Constitution* electric system. Accordingly, a research and test program was set up in the laboratory to assist the designers and to prove the electric system before flight. In addition, this mockup would provide a place where the flight engineers, pilots, and mechanics would be able to familiarize themselves with the operation of the equipment.

An electric drive system consisting of four variable-speed d-c motors was installed in the laboratory to power the generating equipment for the aircraft. The various electric systems were set up on panels and installed on suitable racks in the laboratory in a position adjacent to the full-sized working model of the *Constitution* flight engineer's station. Thus the electric systems could be completely tested and operated from the original input out to the generators through the flight engineer's control station to the various items of load equipment. All of the a-c equipment, with the exception of the constant speed drive was tested thoroughly prior to installation in the aircraft. The drive program, however, had slowed up and it soon became apparent that the successful development of a constant speed drive would not be accomplished in time to furnish these units for the delivery of the airplane. The first airplane had been flying with a complete a-c system. However, the power was being generated by auxiliary power units. It was decided to change the primary electric power system to 120-volt direct current. The laboratory mockup helped greatly in this program since the feasibility of the changeover was tried out there before the second airplane wiring was completed. In addition, the facilities of the Lockheed laboratory, which included all of the aircraft load equipment, aided greatly in assisting the equipment manufacturers to develop a complete 120-volt d-c system. The test program also provided an excellent locale for training purposes. Flight engineers and mechanics were able to operate all of the electric equipment and simulate troubles without jeopardizing the actual airplane. In the aircraft, because of the remoteness of the flight station from the actual equipment which is operated, the engineer occasionally doubts whether things are happening. It is interesting to note that the ability to sit in the flight engineer's station and operate switches and at the same time see the equipment function has aided greatly in the instruction of flight engineers as well as helped them to feel confident of the entire over-all operation.

As a result of this complete laboratory test program for two different types of new aircraft electric systems, the aircraft have been flying with a minimum amount of electrical trouble and very few questions have arisen about operational maintenance from the operating personnel. The first day of flight for the *Constitution* resulted in four takeoffs and landings with a total time in the air of more than five hours. There was not one electrical trouble during this time. Since that time, the second airplane with a 120-volt d-c system also made its first flight without any accessory troubles.

Magnetic Minesweeping Systems; *J. F. Condon, H. M. Koslow* (*Bureau of Ships, Navy Department, Washington, D. C.*).

The first so-called secret weapon of World War II was the magnetic mine. This type of mine lay dormant on the bottom of the sea until actuated by a change in the ambient magnetic field. This change caused either a "compass-needle-like" element to move, closing an electric circuit, or the change in magnetic flux set up an electric current in a coil in a manner similar to that which takes place in a transformer. The electric current flow then detonated the mine.

Two countermeasures for this hidden weapon evolved: degaussing, and the subject of this paper, magnetic minesweeping. The latter took many forms at the inception of its period of evolution, but one arrangement proved most satisfactory and it ultimately became the standard. This arrangement is described in the following.

Using the principle that a magnetic field results from flow of current through a cable, it was considered that an electric cable, which would have the combined characteristics of being buoyant and of being capable of carrying high direct currents, could be streamed from the stern of a vessel. Then, if this cable were energized from a d-c source and a sea-return used to complete the circuit, a magnetic field sufficiently strong to actuate magnetic mines in the area would result. A resultant magnetic field occurs since any increment of magnetic field set up by passage of current in the water on one side of the cable is cancelled out effectively by the increment of field set up by passage of current on the other side of the cable.

Although storage batteries were used as the source of power in the initial magnetic minesweeping systems, installations of this nature were replaced by those of a Diesel-generator type as soon as production would allow. It was not necessary to have the cable energized continuously since a magnetic mine would be actuated after a short period of submission to the magnetic field and the speed of a minesweeper was sufficiently slow that complete coverage could be obtained if the cable were energized with periodic pulses of current. Advantage was taken of this intermittent mode of operation by charging the storage batteries during the off-time in the former type of installation, and by obtaining more horsepower from the Diesel generator assembly through using a large flywheel in the latter arrangement. The fly-wheel inertia provided an output of approximately 550 kw from a 500-horsepower Diesel during each "on-time." Also, some mines were designed to operate on a

reduction in field—as would result from passage of an overdegaussed ship. Therefore, the pulsing mode of operation allowed for reverse pulsing to provide for the sweeping of mines set for actuation from an overdegaussed, in addition to an underdegaussed, vessel. Whereas in the battery type of installation, contactors to break the full minesweeping current were required, pulsing and reversing operations using the Diesel generator installations were conducted through exciter field control.

A major problem in the design of the magnetic minesweeping system evolved about the necessity for obtaining insulated cable which would meet the following requirements:

Have a specific gravity less than that of water.

Carry an effective current of at least 2,000 amperes.

Be sufficiently flexible to allow for storing, between sweeps, on a six-foot diameter reel.

Be sufficiently strong structurally to withstand the rigors of minesweeping operations, including the effect of nearby mine explosions.

The basis for the development of a self-buoyant cable was the use of a flexible, buoyant core over which were placed concentric layers of conductors, with a synthetic rubber sheath over-all. Various types of core elements were used including tennis balls, metal cans, hard cellular rubber elements, and hollow plywood cylinders. Both aluminum and copper conductors were used. Two designs finally were adopted as standard. One was a concentric cable using aluminum conductors; the other a single conductor cable with copper conductors. A core made up of hollow plywood cylinders alternated with soft cellular rubber spacers is now our standard and will remain so until a more suitable material is found.

The cable was terminated by an electrode consisting of 150 feet of 700,000-centimeter bare copper cable in order that the electric current might be passed into the water.

In order to displace the magnetic field set up by passage of electric current from the vicinity of the vessel, a cable similar to that described in the foregoing was streamed adjacent to it for approximately 700 feet, the former cable being approximately 1,600 feet long. Each cable was terminated by an electrode as described in order to complete the circuit through the sea water.

Off-Peak Control of Water Heaters on Rural Power Systems; *H. W. Kelley, O. W. Zastrow* (*Rural Electrification Administration, United States Department of Agriculture, Washington, D. C.*).

The control of storage-type electric water heaters for the purpose of reducing peak distribution loads is receiving additional study, because of power shortages and because of the increasing demands being imposed on electrical generation, transmission, and distribution facilities.

Electric water heater loads were measured on two rural distribution systems, to determine the contribution of the heaters to system peak loads and to gather other information about rural distribution loads due to storage-type water heaters. Approximately 100 water heaters were included in each set of measurements. The heaters were controlled by carrier current transmitters, permitting simultaneous switching of all heaters for the load studies. Recording wattmeters at the substation or metering point showed the changes in distribution system load due to switching of the water heaters. An automatic timer was used to cause all water heaters to be switched off for one minute each hour. Measurements were made with the water heaters operating normally, excepting for hourly measurements, and also with the water heaters cut off during evening peak load periods.

Measurements were made on a number of the individual water heaters served by each system, to supplement the information obtained by metering the system load.

Table I. Summary of Test Results

	Oakdale*	Steuben**
General Data:		
Dates of test periods	Sept.-Oct. '47	Nov.-Dec. '47
Miles of line	909	363
Consumers connected	2,387	1,693
Total energy sold, kilowatt-hours per month per consumer	117	152
Monthly peak demand, kilowatts	1,145	1,008
System Water Heater Data:		
Consumers with water heaters	106	110
Average water heater size, gallons	45	57
Average connected load, lower elements, watts per heater	1,070	1,970
Average measured load during peak, watts per heater	520	600
Average load picked up after three hours off, watts per heater	1,030	1,650
Average energy used for water heating, kilowatt-hours per month per heater	200	220

* Oakdale Cooperative Electrical Association, Oakdale, Wis.

** Steuben County Rural Electric Membership Corporation, Angela, Ind.

Improving Interior Lighting in United States Naval Vessels; *Ernest Boghosian* (*Bureau of Ships, Navy Department, Washington, D. C.*).

Experience acquired by operating personnel in the many vessels comprising the wartime fleet has emphasized the importance of proper and adequate illumination in naval vessels. Severe light contrasts, dark shadows, and glare are some of the more important illumination deficiencies found prevalent throughout the fleet. These deficiencies can be overcome by proper application of lighter tints and by the use of correct values of reflection factors, brightness, and brightness ratios. Joint studies by the Bureau of Ships and various lighting consultants resulted in the adoption of specific standards best suited for shipboard conditions. From these standards several new types of lighting fixtures have been developed. Although the advantages of lower power consumption and heat output of fluorescent lighting are recognized, there are certain inherent disadvantages in shipboard application which limit its use mainly to those living and working spaces where eye comfort and seeing conditions are of prime consideration. In carrying out the lighting improvement program it is hoped to accomplish the compilation of a detailed set of instructions so complete that any shipbuilding activity will be able to plan and to install a lighting system that will be thoroughly satisfactory, and the development of a minimum number of new types of lightweight shockproof lighting fixtures.

Light Sources for Projectors; *John A. Bartelt* (*Engineer Research and Development Laboratories, Fort Belvoir, Va.*).

The Engineer Research and Development Laboratories are investigating some of the new high-brightness light sources which have been developed for the motion picture industry such as the superhigh-intensity carbon arc and the compace source mercury lamp with a view to using these sources in the military searchlight. The present standard 60-inch antiaircraft searchlight uses a 16-millimeter diameter positive carbon, operating at 150 amperes with a brightness of 550 candles per square millimeter and has a peak candle power of 600 million candles.

The use of higher brightness sources will allow new searchlights to be developed which will have reflector diameters reduced to 40 or 48 inches, but with the same peak candle powers. The new superhigh-intensity carbons developed by the National Carbon Company will operate at very much higher current densities and very much higher brightnesses; however, water cooling of the carbons is necessary to achieve the maximum brightness desired. The cooling is accomplished by circulating water at the rate of one gallon per minute through jackets which surround the positive and negative carbons very close to the ends of the carbons.

Tests have been made at the Engineer Research and Development Laboratories on 11-millimeter superhigh-intensity carbons operated both with and without water cooling. The brightness achieved by water cooling is less than that measured for the same carbons operated at the same currents without the cooling; however the uncooled carbons cannot be operated at currents of over 180 amperes with a corresponding brightness limit of 1,400 candles per square millimeter. The cooled arc on the other hand can be operated at currents in excess of 200 amperes. Experimental carbons have been operated at 215 amperes with a measured peak brightness of 1,800 candles per square millimeter. In service operation we expect that consistent operation at 1,500 candles per square millimeter is possible.

The significant effect of water cooling is that a greatly reduced crater depth results. The explanation for this is that the core of the carbon is held at a relatively low temperature until just before it reaches the arc. Since the instable operation of the carbon arc at its maximum current is a function of crater depth, the shallower crater allows operation at current densities very much higher than are possible in the uncooled arc thus resulting in higher brightnesses. Further, the shallow crater permits the emission of light over a much wider angle, allowing the use of a reflector with a shorter focal length and a larger collecting angle. Distribution measurements made across the crater show a wide flat portion at the top of the curve indicating that the high brightness achieved covers a considerable area of the crater. The water cooling has an additional advantage in that the position carbon consumption is reduced greatly, resulting in greater life of the carbon trim.

Air cooling has been tried but the results have not been as effective as those obtained with water cooling.

The spectral distribution from the super-high-intensity carbon is similar to that of the uncooled high intensity arc and has a color temperature of approximately 6,000 degrees Kelvin. The spectral distribution is a good approximation of solar spectral distribution and the high intensity arc therefore has found use as a substitute for sunlight in the motion picture industry.

The compact source mercury vapor lamp developed in Germany by the Osram Company and in England by the British General Electric Company and by the British Thompson-Houston Company also has been investigated by the Engineer Research and Development Laboratories in the hope that the complicated carbon arc mechanism can be eliminated. British lamps rated at 5 kw have been operated in the laboratories and the peak brightness has been measured at approximately 600 candles per square millimeter.

This is about the same order of magnitude as the brightness of the present 16-millimeter standard searchlight carbon. Future developments in the compact source mercury lamp may lead to brightnesses in excess of 1,000 candles per square millimeter over sufficient area to make these lamps suitable as searchlight sources. However this is not as high as the brightness obtained from the water-cooled carbon arc and substitution of the mercury arc for the carbon arc does not appear to be practical in the very near future.

The mercury arc has a disadvantage in that considerable time is required to warm the lamp up to full output. This advantage can be minimized by prestarting the lamp and then reducing the current to a simmering value. When the lamp is simmering, a shuttered enclosure must be provided to conceal the light emitted.

Mercury lamps always must be operated within enclosures to prevent harm to personnel from explosion of the lamp. These lamps operate at several atmospheres pressure and in case of failure explode with considerable force.

The spectral distribution of the mercury arc lamp is confined almost entirely to bands at specific wave lengths and there is very little if any continuous spectrum. There are practically no lines in the red portion of the visible spectrum but this can be corrected by the introduction of cadmium into the lamp.

These red lines obtained by cadmium are not required for searchlight operation but are required if this lamp is to be used as a source for studio lighting.

The concentrated arc lamp developed by the Western Union Telegraph Company is also of interest as a projector light source. Its brightness is not comparable with either the compact source mercury lamp or the high intensity carbon arc lamp but is higher than that of incandescent lamps. The small size of the source is of value in designing optical systems for small projectors. Experimental concentrated arc lamps have been made with wattages up to 1,000 watts and with peak brightnesses of approximately 100 candles per square millimeter. It is expected that such lamps might have application in 16-millimeter motion picture projectors.

The Development of Power From Atomic Energy; *C. Rogers McCullough* (*Monsanto Chemical Company*).

Nearly six years have elapsed since the first nuclear reactor was started. There has been much talk of the destructive aspects of atomic energy and the problems that it poses for the world. There has been little achievement in the constructive development of atomic energy during this period. Radioisotopes have been distributed for research. Power, the big promise of atomic energy, has yet to be developed and progress is not as rapid as is desired. The Atomic Energy Commission has a program for the development of power from atomic energy, but much greater participation on the part of engineers and industrial concerns is required if this country is to keep ahead in this new field. Additional electric power is needed in the United States. The national average use in urban households in 1946 was 1,370 kilowatt-hours, but in Chattanooga the average was 3,537 kilowatt-hours during the same period and increasing at the rate of ten per cent per year. The world as a whole uses only about one-seventh of the power of the United States on a per capita basis. There are enormous potentialities for world co-operation in the expansion of power resources for the world as a whole. Estimates have been made which show that atomic power might cost from 30 to 87 cents per kilowatt-hour as compared to 57 to 75 cents per kilowatt-hour from coal at present coal prices. At this time there is sufficient knowledge to start the design of an experimental power reactor. There is a promising approach to every problem known at this time. A great deal of work is yet to be done including research and development on materials, testing of materials and design, and the fabrication of the necessary parts and equipment for a nuclear reactor, as well as the solution of extremely difficult problems of manpower and administration. The situation with regard to fissionable material reserves of the world is confused, but there are indications that there is sufficient for at least a moderate development of power from nuclear energy. In any case there is sufficient material for the experimental reactors which are required to study the power problem from atomic energy adequately. A few of the bare essentials of a nuclear reactor design are given by the preliminary design of a hypothetical reactor. By the use of this example (the dimensions and quantities are arbitrarily chosen) the problems which must be met and solved are illustrated. These problems include the design of the moderator structure, the design of the fuel units, the support of the reactor, shielding, the heat transfer problem, the feeding and discharging of fuel units, circulation of the cooling gas, and the conversion of the heat in the gas to steam and thus power. These are all discussed in general terms since no specific data can be given. To illustrate that the problem of power from nuclear energy can be solved by the engineering approach a group was formed at Clinton Laboratories at Oak Ridge, Tenn., to work on an experimental reactor. This group was borrowed from industry and studied reactor design in the manner which was illustrated. Although the Atomic Energy Commission's program on reactor design is a start in the right direction, much greater participation on the part of industry and a greater expansion of the commission's own program must be made if adequate progress is to be secured. A vigorous development of power from atomic energy will strengthen this country in a military way at the same time that it is contributing to the peace and prosperity of the world.

Super Energy Particle Accelerators; *M. Stanley Livingston*, (*Massachusetts Institute of Technology, Cambridge, Mass.*).

The particle accelerators now being developed for the artificial production of mesons are for a much higher energy range than previous accelerators such as the cyclotron and the Van de Graaff generator. It now appears that particles having kinetic energies of the order of many hundred million electron volts will be required to study mesons effectively. The machines which give these energies all utilize the principle of phase-stable synchronous acceleration. Of these machines, the best known are the synchro-cyclotron and the electron synchrotron. Synchronous magnetic accelerators all use the same basic principle: repeated acceleration of charged particles while moving in a circular orbit in an axially symmetric magnetic field. In the synchro-cyclotron the usual "dees" provide two accelerations per revolution; however, the resonance relation between magnetic field and accelerating frequency is disturbed by the relativistic increase in mass of the positive ions. This is compensated by varying the frequency so that the particles remain in resonance during acceleration to larger and larger orbits in the essentially constant magnetic field. Electrons, being much lighter, acquire an essentially constant velocity at a few million volts energy so that regardless of the strength of the magnetic field, the angular velocity is a constant. This means that the electron synchrotron can be driven by a constant-frequency oscillator while the magnetic field increases in time and electrons gain energy. The acceleration in the synchrotron is provided by a gap at one point in the point across which is imposed the constant-frequency electric field. The adaptation of the synchrotron principle to the acceleration of protrons requires both an increasing magnetic field and a variable frequency for the accelerating voltage. The frequency must be accurately controlled so that it matches the increasing magnetic field. Proton synchrotrons for energies of several billion electron volts are now in the design stage at several laboratories. The equations of motion have been analyzed to show the type of motion resulting from the superposition of electric and magnetic fields in the case of these several synchronous accelerators. Phase focussing and particle oscillations also are analyzed to show the size of the envelope of the rotating ion beam. Techniques will be described for producing the desired motions and illustrated by existing designs.

Instrumentation and Techniques for Protection From Radiation Injuries; *Karl Z. Morgan* (*Oak Ridge National Laboratory, Oak Ridge, Tenn.*).

The development of nuclear energy in the United States during the war period was accelerated by the central objective of producing in a limited time an effective military weapon. Because of this type of development many conventional, carefully con-

sidered, step-by-step methods had to be bypassed and as a result instruments, radiation shields, protective devices, maximum permissible exposure levels, and new radiation techniques had to be placed into use without subjecting them to the usual processes of evolution. A new science known as "health physics" was evolved for the purpose of preventing radiation damage. The radiation detection instruments used in these measurements are grouped into personnel monitoring, survey, and waste monitoring instruments. In spite of the rapid expansion in the field of nuclear energy, no known radiation damage has resulted to anyone working on any of the plutonium projects.

Progress in Air Transport Radar; *E. W. Harrison (Lieutenant Commander, United States Navy).*

During the past two years the Navy, Air Force, and commercial air lines have been flight testing two wartime radars to determine "what" features are required for a transport aircraft radar and "how" such a radar can contribute to safety of flight. Also at the same time joint Air Force–Navy programs have been underway to produce suitable radars for transport aircraft, the specifications of these radars being based upon the results of the flight testing program. Under one of these programs which is under the technical cognizance of the Navy, the *AN/APS-42* radar is being engineered for production. Evaluation of the military radars has established requirements for the following features which have been incorporated in the design of the *AN/APS-42* radar:

A simple, readable indicator. To present pictorial information in such a fashion as to require a minimum of interpretation a *PPI* (3600-degree polar display) with positive identification of the range scale was utilized.

Switchable CSC²—pencil beam antenna. Either type of pattern is selectable at the discretion of the pilot.

Stabilization of the antenna in roll. This permits banking of the aircraft without loss of the radar presentation.

Increased transmitter power and receiver sensitivity. This yields greater range for beacons, land mapping, and weather detection.

Quick-neutral stabilization position. This permits use of the radar as an artificial horizon in the event of instrument failure.

Five-microsecond pulse. This pulse is used specifically for detection of weather.

Evaluation of the military radars has established that a transport radar can serve the following useful functions:

Map painting. The radar presents a picture of the terrain which is useful for navigation.

Drift angle determination. Regardless of weather conditions the drift angle can be determined from radar intelligence.

Ground speed determination. With recognizable terrain features, radar makes it possible to follow a track through darkness or overcast.

Wind data determination. From information obtained with radar, a pilot can check wind velocity and direction without leaving the course.

Beacon homing. Radar is equipped to give slant range and relative bearing of radar beacons making it simple to navigate or home on the beacon signal.

Terrain clearance. The safety circle feature of the pencil beam enables a pilot even in unfamiliar terrain safely to avoid mountains and peaks.

Aircraft avoidance. To some degree radar will warn a pilot of another aircraft in the immediate vicinity.

Weather avoidance. Since radar detects precipitation or the presence of moisture, it warns a pilot of a thunderstorm or weather front.

Some of the transport radar problems that still remain to be solved using unclassified techniques are as follows:

A daylight viewing indicator.

The ability to determine whether a weather echo is dangerous, that is, is it associated with turbulence and/or hail.

An automatic collision warning device that will be completely reliable.

Further reduction of weight and size of the equipment.

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department.

A Report on the Boston–New York Radio Relay System; *Carl A. Borgeson, presented by D. D. Donald (both with American Telephone and Telegraph Company, New York, N. Y.).*

This report is a condensed summary covering the Bell System's experience in operating the Boston–New York radio relay system. The relay system employs seven intermediate repeater stations. It was engineered on the basis that no path would exceed 35 miles and that first Fresnel Zone clearance would be provided. The over-all system length is 220 miles. It operates in the 4,000-megacycle common carrier band, and provides two broad-band channels in each direction of transmission about 4.5 megacycles wide and capable of handling multiplex telephone or television signals. Low index frequency modulation is employed and intermediate frequency amplification is accomplished in the 65-megacycle region. Highly directive horn-fed shielded lens antennas are utilized throughout. Only four frequency assignments are required by the four one-way channels. The assignments employed are 3,930, 3,970, 4,130, and 4,170 megacycles. The initial multichannel telephone experiments were made using 12-channel *K* carrier equipment in the frequency range 60–108 kc. More recently *L* carrier supergroup equipment operating in the frequency range 1,060–2,044 kc, has been used to provide a total of 240 telephone channels per broad-band radio-relay channel. All circuits met commercial requirements. In one interesting experiment 12 round trips were connected in tandem for a total of 5,280 miles. The resulting circuit was of adequate commercial grade. Principal use of the system is for transmission of television programs. Fading data in the 4,000-megacycle region have been obtained on all paths. The data taken on the first path out of New York, a 35-mile path, indicate that the received signal strength is more than 20 decibels below normal less than 0.05 per cent of the time. The system corrects for such fades and provides adequate signal-to-noise ratio when they occur. The data also indicate that the most severe fading takes place between 11 p.m. and 8 a.m., an unimportant period from the standpoint of television programs.

Midwest General Meeting Conference Papers Digested

These are the authors' digests of most of the conference papers presented at the AIEE Midwest general meeting, Milwaukee, Wis., October 18–22, 1948. The papers are not scheduled for publication in AIEE PROCEEDINGS or AIEE TRANSACTIONS, nor are they available from the Institute.

Recent Developments in the Design of High-Energy Accelerators for Atomic Particles; *J. T. Wilson (Allis-Chalmers Manufacturing Company, Milwaukee, Wis.).*

The greatest advancement in the designs of high-energy particle accelerators has been made by those scientists who have placed particle sources within a magnetic field. It is now possible to classify particle accelerators into three main classes: accelerators employing no magnetic field; accelerators employing a constant magnetic field; accelerators using a changing magnetic field.

The cyclotron and synchro-cyclotron are suitable for the acceleration of the nuclei of elements of low atomic number, and the betatron is best suited for the acceleration of electrons. The synchrotron is suitable for the acceleration of electrons of atomic nuclei.

The betatron is used in industrial applications as a tool for radiographic inspection of thick forgings and castings in ferrous and non-ferrous materials. It has advantages, including useful penetration up to 20 inches of steel; sensitivity of flaw detection which is independent of the total thickness of the specimen; small focal spot yielding critical definition upon photographic plates; short exposure time due to abundant radiation confined and concentrated within a narrow cone; energy of radiation distributed within the band of the spectrum most suitable for efficient penetration of iron and copper.

The Columbia Long Playing Microgroove Recording System; *P. C. Goldmark (Columbia Broadcasting System, Inc., New York, N. Y.).*

The Columbia long playing microgroove recording system was developed to fill the need for uninterrupted music reproduction of better quality at a reasonable cost. This all important factor of cost and the public's familiarity with the handling of phonograph records made it desirable to solve the task on the basis of records, rather than tape or wire.

Standard 78-rpm records originally were designed to generate sound mechanically by direct transfer of energy from the groove of the record to the vibrating diaphragm. The weight of the diaphragm and armature, together with the acoustical reproducer, resulted in high needle pressures requiring large stylus diameters. The latter made necessary the use of the high-speed turntable (78 rpm) in order to allow for sufficient frequency range and a minimum of distortion.

The new Columbia recording system, comprising a commercial player attachment engineered by Philco, was an inevitable out-

come of the use of electrical amplification between the groove deviation and the loudspeaker. Today, practically no mechanical energy needs to be extracted from the groove, and thus entirely different considerations could enter into the design of the new system.

The History and Present State of the Application of Matrix Algebra in Electric Circuit Analysis; *Myril Reed (University of Illinois, Urbana, Ill.).*

Mathematically, matrices are used to study systems of algebraic and differential equations. The famous work of Schrödinger and Heisenberg in connection with quantum mechanics is couched in the language of matrix algebra.

The noncommutative character of matrix algebra is noted and in such relations as $AB=0$ and $A(B-C)=0$ it is noted that A and B neither may be zero in the first nor need $B=C$ in the second.

Kron's work on electric networks is to be noted. Three basic fallacies of his presentation are seen. The inverse of his C transformation does not exist, the currents in his primitive and actual networks cannot be related by a matrix of elements 0, +1, −1, and his transformations are not under power invariance.

The present-day usage of matrix algebra should be approached from the point of view that it aids analysis in systems typified by symmetrical components and the transient study of n-mesh networks. Its chief virtue is condensation.

Circuit Analysis in Servomechanism Theory; *C. N. Weygandt (University of Pennsylvania, Philadelphia, Pa.).*

The applications of circuit analysis and synthesis techniques not only in servomechanism theory but also in the closely allied field of process control suggest the possibility of wider applications in the future.

The performance of a servomechanism, which is either an electromechanical system or an all mechanical system, is determined by a set of differential equations. If these equations are linear with constant coefficients, or if they can be made so by assuming that the variables undergo small changes in the neighborhood of a fixed operating point, then all the techniques of circuit analysis may be applied to servomechanisms. This is true because the performance of an electric circuit also is governed by a set of linear differential equations with constant coefficients.

Concepts such as driving point and transfer impedances and admittances, response of circuits to step, and impulse functions all can be applied to servomechanisms. Powerful mathematical tools, such as Laplace transforms, Fourrier integrals, and some of the theorems of the theory of functions of a complex variable have been used in the analysis and synthesis of electric networks. These, too, are applied to servomechanisms.

A perfect analogy exists between a servomechanism and an electric feedback amplifier. The techniques of feedback amplifier design developed by Nyquist and Bode find wide application in the design of servomechanisms. The concepts of equivalent circuits widely used in circuit analysis as aids in computation, and in the use of models such as network analysers, also have been applied in the servomechanism field.

The use of equivalent circuits whose responses to controlling influences are analogous to the responses of processes to be controlled is an approach which eventually will make possible the precise design of a process control system. This approach has been suggested and carried out in simple cases by G. A. Philbrick.

Designing Boiler and Control Equipment for Fluctuating Loads; *P. S. Dickey (Bailey Meter Company, Cleveland, Ohio); P. R. Loughin (Babcock and Wilcox, Ohio Division).*

While all modern steam boilers are capable of handling load fluctuations of reasonable range and rapidity, certain types of steam generators due to special operating conditions must be capable of extremely fast and wide range load changes. Conditions which call for this type of steam generating plant are as follows:

1. Central stations which supply power to a utility system in which a large proportion of the power generating capacity utilizes water power and long-distance transmission systems and is thus subject to instantaneous stoppage due to transmission line failures.
2. Marine boilers of all kinds must be capable of fast changes in load over a wide range because of the need for maneuvering the ship.
3. Locomotive boilers are subject to considerable load fluctuations and thus far have been built with large water storage to compensate for the lack of responsive firing equipment.

The reasons for the extreme differences in design between mobile and stationary units for fluctuating loads can be summarized generally by the following:

Mobile Units: Prime considerations are space, weight, and reliability; secondary considerations are initial and operating cost, and life.

Stationary Units: Prime considerations are reliability, initial and operating cost, and life; secondary consideration is space.

The following factors govern the pick-up time of a steam generating unit:

1. The accumulator action which depends upon the water and metal storage of the boiler.
2. The temperature rise in the boiler water and metal parts encountered from low to high ratings on the boiler.
3. The time required to accelerate the steam release which depends upon arrangement of the steaming surface and the rate of circulation.
4. The time required to accelerate the rate of combustion as determined by fuel burning equipment and auxiliaries.
5. The practical and economical limit of overfiring which can be applied.
6. The permissible drop in steam pressure as determined by turbine and boiler design.
7. The allowable drop in system frequency.

In general, any of the commercial fuels may be utilized in furnaces for boilers designed for rapid fluctuating loads. Generally, the type of fuel and fuel burning equipment affects the extent of operating range more than the speed of response. Careful consideration must be given to design of draft equipment for boilers for fluctuating loads.

In general, the automatic control equipment used on a boiler designed for rapidly fluctuating loads is similar to that used on the usual installation. However, the demands on the automatic control are much more severe and the combustion and feed water control as well as the steam temperature control must be arranged to meet the special problems resulting from rapid load fluctuations.

It is the opinion of the authors that considerable progress has been made in the development of conventional designs in boiler units and control equipment to adapt them to the special requirements of fluctuating loads. The interrelationship of controls and boiler designs is so important that close co-operation between the boiler designer and control designer is necessary to obtain best results. In order to obtain the most economical over-all combination for units required to meet extreme and rapid fluctuations, the turbine designer must participate so as to obtain the best balance between turbine and generator output at reduced steam pressures versus storage capacity or overfiring capacity of the boiler.

New York to Schenectady Television Relay; *F. M. Deerhake (General Electric Company, Schenectady, N. Y.).*

A booming television industry in 1948 still is wrestling with the problem of programming stations, particularly those not located in the major metropolitan centers, without encountering prohibitive production costs. As a step toward network operation, General Electric's Schenectady, N. Y., station, *WRGB*, found it possible, beginning in 1940, to receive and rebroadcast programs from *WNBT* in New York City even though true optical line of sight from New York City passed nearly 7,000 feet over the area in the Helderberg Mountains near Schenectady where the *WRGB* transmitter was located. This arrangement, while highly satisfactory in many respects, was subject to several disadvantages and finally became impractical because of the shift of frequency of *WNBT* to the same channel as *WRGB*, in 1946, which created an intolerably high interference level at the receiver located only a mile from the *WRGB* transmitter.

The necessity for a higher quality relay system as a permanent solution already had been realized and work was well advanced at 2,000 megacycles. Here was found a combination of advantages not possessed by either higher or lower frequencies, antenna gains of the order of 1,000 to 1, allowing use of a low-power transmitter, but less sensitivity to atmospheric conditions than is prevalent at wave lengths much shorter than ten centimeters.

A 4-link path was laid out between New York and Schenectady with links of 51, 53, 26, and 13.5 miles respectively. Identical towers were erected on the three intermediate sites. Radio equipment installed in each of the three towers was identical, consisting of a 6-foot parabolic reflector directed southward for the receiving antenna; the receiver, installed in a temperature-controlled cabinet, and its power supply; the transmitter, also installed in a temperature-controlled cabinet, and its power supply; and a second identical reflector, directed northward, for the transmitting antenna. To complete the system, a set of transmitting equipment was installed atop the General Electric Building in New York City and a set of receiving equipment at the *WRGB* studio site in Schenectady. The transmitter uses a reflex klystron, frequency-modulated to a total swing of 10 megacycles and having 5 to 10 watts power output.

Including an initial period of experimental operation, the relay system now has been programming *WRGB* for a large percentage

of its operating time for well over a year. No failure of the circuit definitely attributable to signal fading caused by atmospheric conditions has occurred, although some variation in signal strength has been noted during heavy storms. As might be expected, no interference problems in the 2,000-megacycle range have been encountered because of the general scarcity of equipment operating in that range.

While much of the permanent television network operation must go into those facilities operating as common carriers on the frequencies assigned for common carrier applications, the field for privately owned short relay systems is not closed, and 2,000-megacycle equipment offers attractive advantages in consistency of propagation and in cost where a few relatively long relay links can cover the required distance.

Recent Development in Semiconductors and the Transistor; *J. A. Becker (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).*

The electrical properties of metals and insulators have been known for a long time. In the last decade the electrical properties of semiconductors have been intensively investigated. These semiconductors are solid materials whose electrical conductivities lie between those of metals and those of insulators. Concomitant with these investigations, important applications of semiconductors have been developed. These include copper oxide, selenium, silicon, and germanium rectifiers, modulators, voltage limiters, expandors and compressors, thermistors or thermally sensitive resistors which are used as temperature controls, time delay devices, automatic gain regulators, oscillators, and 2-electrode amplifiers.

The most recent development stemming from the research on semiconductors is the transistor, which consists of a small piece of semiconductor with three electrodes. This device amplifies input signals in somewhat the same way as does a vacuum tube. Power gains of a factor of 100, or of 20 decibels, are attained. Frequencies up to 10 megacycles per second can be amplified. Output powers of 5 to 20 milliwatts are realized. Experimental models of transistors are only 3/16-inch in diameter and 1/2-inch in length. They do not have any hot cathode and require no heat-up time. Transistors also can be used as oscillators.

Transistors cannot be substituted in the same circuits for vacuum tubes. Their input impedance is much lower, up to several hundreds of ohms. Their output impedance is in the range of 10,000 to 40,000 ohms. The noise per cycle band width at 1,000 cycles per second may be 60 decibels above thermal noise for an equivalent impedance. It decreases as 1/frequency.

It is possible to describe the a-c performance of a transistor in terms of an equivalent circuit containing three resistances and a generator. The constants of such a circuit depend upon the d-c operating conditions and vary from one unit to the next.

An A-C Operated Magnetically Latched Contactor; *L. H. Matthias (Allen Bradley Company, Milwaukee, Wis.).*

The contactor is similar to the conventional a-c operated magnetically held type, except that the magnetic circuit is partially constructed of a permanent magnet steel. The remanent flux remaining in the magnetic circuit after the closing interval holds the armature in the closed position. Latched contactors employing this principle, but operable only from a d-c source, are well-known. This limitation is removed by the present device, which permits reliable operation from alternating current.

A high and uniform value of remanent flux with the armature in the closed position may be obtained by designing the magnetic structure with a sufficiently high remanent flux and coercive force, and by insuring that the coil current is broken at a current zero after the armature is in the closed position. This involves a proper selection of permanent magnet steel for the magnetic circuit, an auxiliary switch which opens the coil current uniformly at a normal current zero, and operation of the magnetic circuit at high densities during the closing or magnetizing interval.

The contactor may be opened or the armature released by applying a small alternating magnetomotive force in the magnetic circuit. A considerable range in this demagnetizing magnetomotive force is possible, and thus allows satisfactory operation over a wide range in line voltage.

Safety in Machine Tool Control; *D. K. Frost (Mattison Machine Works, Rockford, Ill.).*

During the passage of each year, statistics reveal a surprisingly large number of "on the job" occupational deaths and accidents. The percentage of these chargeable to faulty control is relatively small; however, it is serious enough to call for the best efforts of engineers on safety features.

The elimination of fatalities due to hazards inherent in the use of electricity has been furthered during the war years and since by a strict compliance to a code written in 1935–36 by a committee of the National Machine Tool Builders' Association. During the war this code was made a war standard for machine tools.

Due to rotation of membership on this committee and the intense interest in the preparation of an adequate code, the resulting betterment in quality of wire insulation, wiring methods, better grade of fittings and control accessories, dust-tight push buttons and limit switches, and functional improvement of relays, switches, and interlocks has been most notable. In fact, advances which normally would evolve in a number of years have been secured in a few years. These advances are due wholly to a free interchange of ideas and experience between committee membership and groups and the interest and following of the code by a majority of the member companies. Also from pressure on electrical manufacturers for better and safer control accessories, fittings, conduit, enclosing cases, and other items too numerous to mention. This has been an orderly and much needed accomplishment.

Parts of the code have become embedded in the National Code of the Fire Underwriters under Article 670—Machine Tools. The code recently has been amplified by the automotive industry, not only for machine tools but for all industrial applications of motors with their control.

The hazards from functions of machines varies widely for each type and must be covered by a careful study of the cycles of the particular machine from a safety standpoint. Functions which all machines have in common involve proper control items to guard against unexpected starting after power outages or careless operation. Also, machines must stop safely after incorrect cycle sequence, tripping of final limit switch, overload, power failure, or stalled motor or motors.

Failure of contacts probably has caused more fatalities than any other hazard, and the cause and cure for this evil demands attention as also does the adequate grounding of machines and electric circuits. It is apparent that adequate codes and strict adherence to such codes is a procedure which has and will produce the best resulting safety for operators and machines alike.

Some Machine Tool Electric Control Applications; *Leonard Hesse (Gisholt Machine Company, Madison, Wis.).*

One of the earliest problems in machine tools was maintenance of the operating controls. As the machines and tooling gave higher and more accurate production, the various controls became more complicated. Mechanical controls were adequate for a while, but as the number multiplied it became a serious problem to fit them in a compact area in such a manner as to make them readily accessible for maintenance. Electric controls not only reduced the number of machine parts, but made maintenance a relatively simple job for the average electrician.

Another problem was brought about by machine standardization. In order to bring machine costs down it became necessary to make the basic machines as simple as possible. Then, through the addition of various tooling combinations, the machine was adapted to specific jobs. This required a very wide variety of tooling and caused the use of many new air and hydraulic controls. These in turn necessitated the use of highly accurate, electric operating controls.

The history of the development of Gisholt's machine tools is tied in very closely with electric control developments. Each new use for a machine added new tooling ideas. Each new tooling idea required additional operational controls and occasional machine changes. The machine changes are quite obvious, but only a person actually working with wiring diagrams and controls can fully appreciate how closely related they are.

Electric control elements usually are selected to provide the maximum utility with regard to accuracy required, dependability of service, safety to the operator, ease of maintenance, flexibility of adjustment, and simplicity of the resulting arrangement.

Determination of Heat Requirements; *M. M. Greer (Edw. L. Wiegand Company, Pittsburgh, Pa.).*

The heat requirements for any process heating application are calculated by using the basic heat formula: Btu = weight in pounds × specific heat × temperature rise in degrees Fahrenheit. This calculation will cover conduction or contact heating jobs; immersion heating jobs; and air heating jobs. Additional factors such as heat of fusion and heat of vaporization and heat losses must be calculated.

The initial heat requirements are calculated to determine required heating capacity

or the number of hours allowed for the initial heating. The operating heat requirements are calculated to determine the necessary heating capacity to carry on the heating process after the required operating temperature has been reached.

A comparison of the initial heat and the operating heat requirements is made and a heating capacity selected that will take care of both heat requirements. This may mean allowing a longer initial heating period in order to reduce the installed heating capacity or, if the operating heat requirements are large, it may mean a large installed heat capacity with a short initial heating time.

Electric Heating of Fluids; *Lee P. Hyne (Hynes Electric Heating Company, Camden, N. J.).*

Modern industry uses fluids which vary greatly in their reaction to heating, especially in the higher temperature and pressure ranges. Viscosity, conductivity, surface film, velocity of flow, tendency to carbonize or crack, chemical and physical changes, corrosion, fire and explosion hazards, and many other factors must enter into the engineers calculations when designing successful installations for fluid heating.

The energy output from an electric heater is inherently uniform and can be represented by an approximately straight line regardless of the ambient temperatures surrounding it. This means the temperature of the heater itself is represented by an ascending curve and makes it necessary to safeguard against temperatures high enough to damage the fluid being heated.

An electric heater differs from a steam heater in this respect. In the latter the heat output decreases with temperature rise and must be represented by a descending curve which reaches zero when the ambient temperature equals the steam temperature. The engineer must design an electric fluid heating system with full knowledge of temperature affects on all the materials involved. He also must provide adequate means to prevent exceeding safe temperatures in the heater and in the fluid being processed.

Direct electric heating employs conduction and radiation to transfer the energy directly from the electric heater to the work being processed and such a system is subject to the conditions described. Indirect heating employs a circulating fluid medium or bath, such as water, heat transfer oil, Dowtherm, or other suitable stable fluids having good heat absorption and carrying qualities. This circulating fluid transfers heat energy from the electric heater to the work being processed.

A bath of this kind stabilizes temperature changes as it can be regulated by automatic control more easily than a direct heat transfer system can be regulated. Circulation is important both in the bath and the work fluid being heated, and usually is accomplished by pumps and mechanical agitators.

Radiant Heating; *H. J. Garber (University of Tennessee, Knoxville, Tenn.).*

During the past decade the utilization of the infrared radiant heating lamp has grown to where the existing installations approximate some 400,000 kw with an annual energy consumption of about 600 million kilowatt-hours. An estimate of applications that can be made to other fields indicates that there exists in the United States a potential for about three million kw of infrared radiant heating installations with an annual energy consumption of some four billion kilowatt-hours. Significant expansions of the use of infrared radiant heating can be made successfully and economically in some of the following fields: processing and manufacturing of wood and furniture, plastics, paper, natural and synthetic textiles, leather, foods, heat-treating of fiber and metals, pharmaceuticals, rubber, metal plating, ceramics, printing and lithography, explosives and propellants, laundering, electric appliances, and adhesives among others.

The more expensive combined radiant and convection oven equipped with insulation, reflectors, shields, air curtains, regulated air flow, curtains, and heat recuperators as compared with the typical open tunnel type of infrared oven is in reality not more expensive than the latter, if items other than initial installation costs are considered. Using typical current costs for equipment, maintenance and operation, and energy charges, it was demonstrated that the added equipment expenses for the added features enumerated for the short-cycle heating oven pay for themselves in about three to four years, and that from then on significant savings result. This is in addition to other advantages in favor of the short-cycle heating oven.

Comparisons of the mechanisms of radiant and convectional were made. It was shown that to maximize the advantages and minimize the disadvantages of both of these types of heat transfer, neither of which can be divorced from the other in infrared heating, the most suitable type of equipment is the short-cycle heating oven.

Dielectric Heating; *W. H. Hickok (Girdler Corporation, Louisville, Ky.).*

A study has been made of some of the factors influencing the speed and efficiency of edge-bonding lumber by dielectric heating energy. It has been found that the lowest frequency that it is possible to use without danger of arcing delivers the energy to the glue line most efficiently.

The effect of the voltage upon the cure cycle also has been studied and found to be somewhat independent of the frequency being used. The cure time cycle varies inversely with the voltage. The efficiency of this operation is greatly influenced by the time cycle chosen. A long time cycle permits energy in the form of heat to flow from the vicinity of the glue line, and consequently requires a greater total amount of energy for curing the glue.

An example of a typical press divides the energy into that which is productive and that which is nonproductive. This particular example can be developed further to show how the effective ohmic resistance of the glue line may be determined. The ohmic resistance of the glue line is found to vary from the start to the finish of the cure cycle. The values are found to be 4,000 to 10,000 ohms per linear foot as the cure cycle progresses. These values refer to a glue line that is one-inch high. The conditions of this example indicate an energy input to the glue line of approximately 170 to 115 watts per linear foot as the glue cures.

Conclusions drawn show that the frequency should be as low and the cure cycle should be as short as feasible. Experience indicates that good operating results may be obtained at 5 megacycles utilizing cure cycle of 30 seconds. The danger of arcing is the factor that imposes limits on the above.

History of the Development of Blooming Mill Drives; *G. E. Stoltz (Westinghouse Electric Corporation. East Pittsburgh, Pa.).*

The first two reversing blooming mills equipped with electric drive were installed in Canada. While the steel industry in the United States is much larger than that of Canada, no doubt the reason for this type of mill being electrified in Canada was because of the wide discrepancy of electric power and fuel cost.

One of these drives was placed in operation in June 1912 and the other in March 1913.

They both consisted of a double armature shuntwound motor with two generators on the flywheel set. The unit installed in 1913 had laminated generator frames. The first installation made was equipped with a face-plate controller that handled the field current of the generators and the double armature motor. The second one installed was equipped with contactors in the field circuits of the generators and motor. These contactors were operated by a drum-type controller located in the operator's pulpit.

It was found the laminated generator frames were too fast to reverse the motor as very high peak currents were drawn if the controller was reversed too rapidly. The maximum currents obtained were usually during acceleration or retardation.

In 1914, two reversing blooming mill equipments were sold in the United States, one for a light 34-inch mill using a single-armature 3,500-horsepower 50- to 120-rpm reversing motor supplied with power from one generator. The second mill sold in 1914 was used to drive a heavy 35-inch mill, and was equipped with two armatures on the motor shaft. The power supply came from two generators on the flywheel set. Both of these motors were compound-wound, which effectively stabilized them so as to greatly reduce the reversing a-c peaks.

The next step in the design of reversing equipments was to provide current limit control which made it possible for the operator to reverse his control without causing the motor to draw more than a predetermined value of current. Later, single-armature motors were installed supplied with two or more generators. Crossed series fields on the generators were developed to divide the loads between the generators.

In 1930, the first twin-motor drive was installed. This consists of two motors, one to drive the upper roll and the other the lower roll. This eliminates the use of a pinion housing. Later rotating regulators were introduced to take the place of vibrating relays. This new control with twin-motor drive gives very smooth operation.

The Differential Interlock Regulating System for Sectional Paper Machines; *J. L. Van Nort (The Reliance Electric and Engineering Company, Cleveland, Ohio).*

To maintain precise intersection speed relationships and constant linear speed, accurate maintenance of the phase or angular relationship between machine sections is of

paramount importance, both under changes in load and changes within the driving motors caused by field heating, and so forth. Maintenance of constant linear speed of the paper machine is vitally important too; but some lesser degree of regulation can be tolerated without seriously penalizing the paper-making operation.

Reliability of equipment performance is to be stressed, to assure that that not only must paper mill drives run uninterruptedly for long periods of time, but they should be so designed that normal inspections while operating will reveal any impending troubles for which a shutdown should be scheduled.

In the Differential Interlock Regulating system, the general arrangement of power equipment provides a d-c driving motor for each section of the machine. Adjustable voltage power is supplied to each section motor from its individual section generator. A constant source of potential is supplied for excitation of the section drive motor fields, the control equipment, and for the synchronous motors which drive the section generators.

The master reference signal used to coordinate the section motors is a voltage of a fixed frequency not affected by circuit errors or temperature. This reference frequency is produced by an alternator driven by a d-c motor, the speed of which is controlled through a tachometer driven by the alternator. An electronic speed regulator (VSR) is used in conjunction with the tachometer.

The master or reference frequency is used at all sections of the machine. In this way, each driving motor is supplied with a signal of constant frequency which is used through the differential section interlock regulator (SIR) to adjust automatically the speed of the individual section motors. The SIR includes a synchronous motor driven by the reference motor. The output of this motor is compared, through a gearing system, to the speed of the drive motor. Any differences are detected by a differential rheostat. The error signal then is amplified through a VSC electronic excitation unit. This unit receives a signal from the master frequency bus and from the SIR. The signals are compared and amplified electronically, and the VSC output controls the output voltage of the section generator and thus the speed of the drive motor. Additional features of the automatic drive include a draw adjustment built into the SIR, a slack take-up which can be applied to any section, and the automatically controlled acceleration device.

Radiotelephone Service for Passenger Utilizing Bell System Highway Channels; *Newton Monk* (*Bell Telephone Laboratories, Inc., New York, N. Y.*).

The first public radiotelephone service on railroad trains was inaugurated in the United States on an experimental basis in August 1947 on several trains operating between New York, N. Y., and Washington, D. C. This service is provided through the land stations associated with a series of Bell System urban mobile systems located along the route of the trains and utilizes frequencies in the 152–162-megacycle range. Since the Bell System has in operation a number of highway mobile systems which use frequencies in the 30–44-megacycle range, it was believed desirable to determine the feasibility of using such systems for train telephone service. Accordingly, in September 1948 experimental service was inaugurated on several trains of the New York Central and the New York, New Haven and Hartford Railroads, utilizing the New York–Buffalo and New York–Boston highway systems respectively.

The land station transmitters and receivers regularly employed in the highway systems are used for the train service and the transmissions to and from the mobile units are combined and connected to the land lines in the control terminals also associated with the highway systems. For the train service, however, certain modifications in the control terminals were found desirable. These include the substitution of a hybrid coil for the combining network ordinarily employed and the addition of a noise reducer in the receiving branch of the circuit.

The equipment on the trains is similar to that provided for automobiles using the highway systems. There are, however, important differences. Special antennas to meet railroad clearance requirements are necessary. Full duplex operation is employed whereby the push-to-talk arrangement used in automobiles is eliminated. Also, control equipment is included to permit operation of telephone by an attendant.

When these projects were initiated, tests were made in co-operation with the respective railroads to determine whether adequate coverage could be obtained on the railroad routes from the existing highway systems. These tests included 2-way talking tests and measurements of radio noise. The results of the tests indicated that commercial service could be provided over substantially all of both routes.

An interesting feature in connection with the tests was the discovery of a type of noise not experienced to any extent in the 152–162-megacycle band. An investigation of this noise indicated that it was similar to a type of noise termed "stay noise," since it first was observed on ship installations and traced to the movement of the stays. The stay noise is created locally and is probably due to the movement of mechanical contacts and joints in the presence of the strong radio-frequency field near the mobile transmitter. These moving parts become small generators which create noise over a wide band of frequencies including that accepted by the receiver of the mobile unit. The stay noise is sufficiently high to effect materially the coverage obtained in the fringe areas of the several units of the highway systems.

It is concluded that the radio transmission between moving trains and Bell System highway mobile facilities along railroad routes is generally satisfactory for public train telephone service.

Magnetorque A-C Crane Control; *F. M. Blum, F. W. Wendelburg* (*Harnischfeger Corporation, Milwaukee, Wis*).

The magnetorque unit was introduced to the general public in the year 1942 on large excavating machinery. Here the unit was used as a clutch to replace frictional clutches previously used on large earth moving machinery. However, on over head traveling cranes this unit is used as a brake rather than a clutch. A-c powered cranes now provide the same splendid speed control as was thought possible only on d-c powered cranes. In the past, electric overhead traveling cranes have been powered by direct current motors because of the desirable speed characteristics obtained for the hoist motion when using dynamic lowering control. the most recently developed a-c system is magnetorque control. This unique system, utilizing an eddy current brake, compels the hoist motor to operate effectively at reduced speeds.

The mechanical construction of a magnetorque brake and its mounting in the hoist mechanism is completely described. Curves illustrating the development of this control and its final results are given. An analysis of the control circuit taken step by step and the outstanding safety features such as off position braking. As well as the all position auxiliary braking, will aid in revealing the characteristics of the control. This new control actually excells that of d-c dynamic lowering crane control.

Fundamentals of Machine Tool Contouring Systems; *J. M. Delfs* (*General Electric Company, Schenectady, N. Y.*).

Tracer-controlled machine tools are assuming an increasingly important role in our manufacturing industries. Machines of this type employ some form of template or master part to define the shape of the work to be produced on the machine. A closed cycle position regulating system is used to control the operation of the machine so as to duplicate the shape of the template in the work.

By use of the tracer control principle, it is possible to first produce the desired work shape in some soft easily worked material such as wood, plaster, or plastic. The tracer controlled machine can then reproduce this shape in tougher materials such as die steel. For small and medium lot production work, machines of this type can be used to produce a number of identical parts from a single template. With many tracer-controlled production machines, the operation of the machine has been made automatic to the point where the operator has little to do but load and unload the machine.

The closed cycle position regulators used to control the operation of these machines consist primarily of the following basic elements: a tracing head or error measuring device; one or more amplifier elements; a power element consisting of a reversing adjustable speed drive; and a direct mechanical feedback from the output of the system to the tracing head.

The performance of these tracer controlled machines may be defined in terms of tracing speeds and the accuracy of reproduction obtained at these speeds. The major factors determining the performance of these close cycle position regulators are tracing head sensitivity, loop gain or amplification, and system time constants. These factors determine the performance levels which can be attained with satisfactory system stability.

In the practical application of these tracer control systems, the mechanical design of the machine on which the control system is applied is a very important factor in determining the performance obtainable. To meet a wide variety of application requirements, many modifications of the basic tracer controlled machines have been developed.

These modifications make possible such features, as one, two, and three dimensional control and pantograph effect.

Keller Tracer Controls; *J. J. Jaeger (Pratt and Whitney Company, West Hartford, Conn.).*

Keller tracer controls have been used on various sizes of tool room die making equipment since 1919. The Keller control is a contact type, dead space, closed cycle servomechanism. Tracers are made to provide operation in either a single plane of cutting such as would be used for blanking dies and punches or in 3-dimensional operation for forming or molding dies.

The power mechanism for driving the machine slides are motor-driven magnetic clutches designed specifically for high speed of operation and small inertia. Duplication is accomplished by step-by-step approximations of the desired curves, the magnitude of the steps being reduced to the same order of magnitude as the flute marks of the milling cutter.

Recent developments provide, in addition to the magnetic clutches, a variable speed motor drive which automatically adjusts the ratio of speeds of several slides so that the resultant component of two slides will approximate the tangent of the required curve. In addition to the tracer controls, the machines are equipped with a variety of manual and automatic controls.

Simplified Contouring Control for Lathes; *R. E. Schuette (Barber-Coleman Company, Rockford, Ill.).*

The contouring control was designed for field application to existing Le Blond lathes. In order to simplify the equipment which must be added to the lathe, a system was devised whereby contouring could be performed with a single variable movement of the tool, thus requiring only one servo unit.

When this system is employed to contour shafts, a constant lengthwise feed is used. A servo unit, controlled by a stylus which bears against a template, is arranged to move the tool along a line such that it will have a component parallel to the lengthwise feed. The magnitude of the movement produced by the servo will vary in such a way that the constant lengthwise feed plus the variable motion will produce a resultant motion which is at all times parallel to the template surface being contacted by the stylus. When doing profile facing, the same arrangement is used except that a constant cross feed is employed instead of a constant length feed.

The servo unit is mounted on the compound rest and geared to the screw which moves the compound rest on its slide. By means of the swivel slide, the angle of the variable movement can be changed. If it is set so that it has a component capable of completely opposing the lengthwise feed, it will be possible for the tool to move out at right angles to the axis of the work. However, in that case the angle at which the tool can be moved in will be less than a right angle by an amount depending upon the relative values of the length feed and the maximum speed of the servo unit. If it is necessary to turn right angle shoulders in both directions, the work must be removed from the lathe, turned end for end, and a second cut made. This type of work is seldom encountered and therefore the difficulty of turning such a piece was accepted in order to obtain the single control mechanism.

The servo unit which provides the variable movement is of the friction clutch type. Two magnetically actuated friction clutches are used and they are geared together in such a way that the servo output may be driven in either direction, depending upon which clutch is energized.

The clutches use a single, cork faced, driven disk which is clamped between two driving members whenever a current is passed through the clutch coil. The clutches do not provide a positive drive between the input and ouput shafts, but merely transmit a torque when they are energized. In order to obtain very rapid response, they are designed so that no appreciable axial movement of any parts is required upon energization of the clutch.

To smooth out the pulses of torque applied to the compound screw by the two clutches, a friction coupled flywheel is used as a stabilizer. The flywheel is carried on the output shaft of one of the clutches and rotated by a friction-coupling. It therefore assumes a speed which approximates the average speed of that shaft and whenever the shaft speed tends to vary from that average speed, a correcting force is exerted by the flywheel acting through the friction coupling.

The clutch currents are controlled by a single pole double throw switch which is actuated by the pressure between the stylus and the template. Whenever neither clutch contact is made, a magnetic brake similar in construction to the cutches is energized, thus eliminating any hunting of the servo when turning a straight portion of a shaft.

General Electric Contouring Controls for Machine Tools; *Robert D. McComb (General Electric Company, Schenectady, N. Y.).*

The General Electric line of contouring controls include single, two and three dimensional controls in order to best meet requirements of a wide variety of machine tool applications. The tracing heads have no wearing parts, but obtain a modulated signal from one, two or three magnetic bridges; one for each axis of motion to be controlled.

All of the controls use electronic circuits for contouring operation, in order to eliminate wearing parts. The d-c feedmotors (which are geared directly to the feeds), the amplidyne generator, and the machine are the only wearing parts during contouring.

The one-dimension contouring system is a stepless proportional system and is used in many different types of work. The 2-dimension system is a stepless, constant-velocity, constant deflection system. It is used principally for turning operations. The 3-dimension system is a selective 2-dimension system. It is used largely for tool and die work, where ability to contour around any shape that a tool will cut makes it very useful. Contouring may be done in any of three mutually-perpendicular planes and changes from one plane to the other are accomplished with only one switch, and are done without shifting tracing head, templet, work or tool. Manual controls are provided so that the feedmotors may be used for ordinary machining operations.

7J Rotary Telephone Switching System; *R. W. Engsberg (Federal Telephone and Radio Corporation, Newark, N. J.).*

There has been a demand for a motor-driven telephone switching system suitable for smaller communities than are normally served by systems such as the 7A2 Rotary, cross bar and panel. To meet this demand Federal Telephone and Radio Corporation has developed the 7J system.

In the 7J System all selecting mechanisms are of the 100 point Rotary type which has proved to be the most reliable and trouble free switch of the Rotary system. Through the development of new techniques in manufacture and assembly this switch has been adapted for the use as a finder, a group selector, and a final selector or connector. Each switch is driven through a simple flexible gear arrangement which engages a gear attached to a continuously rotating shaft. This arrangement assures constant speed and positive operation.

The 7J system is a revertive pulsing system and the operation of each grade of rank of switches is controlled by means of a register. The operation of the selector switch causes revertive pulses to be returned to the register which then signals the selector to stop on the desired level. By this means pulses from the dial operate equipment in the register only, allowing greater variations in dial speed and line conditions, since only one piece of equipment is involved in the dialing circuit.

New developments in frame construction and methods of cabling have reduced manufacturing and installation cost and thus reduced the ultimate cost to the consumer. The use of lightweight aluminum frames and racks has reduced the weight and effected economically the building construction.

Automatic routine equipment has been designed which makes it possible to completely routine a thousand line office in a few hours with an exact indication on a tape recorder the nature and location of all faults detected.

Organization and Administration of Wide-Area Servicing Activities; *W. A. Goodell (Lorain County Radio Corporation, Lorain, Ohio).*

As an adjunct to their activity of furnishing a ship-to-shore radiotelephone service, The Lorain County Radio Corporation has built up a wide-area service organization covering the Great Lakes. Realizing that the success of any service activity is measured by the availability of its personnel, this company has, through a number of years of development and experience, built up a service group and established service centers at strategic points such that almost continuous repair service can be given at most of the major ports on the Great Lakes.

Most of the ship traffic on the lakes is from the Duluth-Superior area on Lake Superior down through the connecting waterways to either the Chicago area or ports on the south shore of Lake Erie. The nature of this traffic permitted establishment of service centers at Duluth, Minn.; Hammond, Ind. (Chicago); Ashtabula, Ohio; and Lorain, Ohio. From these centers operate one or more servicemen covering as much of the surrounding area as feasible. In addition to these centers there is an inspection station at Sault Sainte Marie, Mich., located at the locks through which the ships pass from Lake Superior to the lower lakes. Here routine inspections of equipment are made as well as minor repairs. Reports of any improper operation then are passed to other service centers for correction.

One of the important features of this service is the system of dispatching requests for

service and the accumulation of reports on work completed. Practically all requests for service are channeled through the main service center at Lorain, Ohio, at which point the service dispatcher classifies the service needed and relays this information to the proper service center or engineer to complete the work.

Reports on repairs made, parts used, time consumed, and so forth, are completed on appropriate forms by the service personnel, which information is returned to the dispatcher for filing against future complaints and for billing purposes.

One of the chief factors contributing to the success of this wide-area service organization was the adoption of a form of service contract whereby repairs and replacement parts, and a routine inspection, are contracted for on a fixed sum per year or month. This formed the basis for a sound financial foundation, allowing a more widespread service and the ability to carry over during dull periods.

Other important factors were the selection of proper service personnel, establishing a spirit of co-operation between groups, and periodic group discussions on ways to improve service.

Introduction to the Topic of Ore Beneficiation; *W. L. Maxson (Oliver Iron Mining Company, Duluth, Minn.).*

In its broadest sense, ore beneficiation comprehends the treatment of ores to improve their quality, which in turn, is normally accomplished by separating undesirable material and preparing the product for the next step toward the ultimate goal, which is the production of metal or one of its compounds. The waste materials may be separated by application of heat, under oxidizing or reducing conditions, by dissolving, and precipitation (electrically or otherwise) and by a great variety of machine applications.

We today largely are concerned with the last group. Ore beneficiation processes usually include as a primary step the reduction in size of the coarse material as it comes from the mine. This is accomplished by crushing, and usually is followed by other stages of crushing and grinding until the original material has been subdivided to such a size that the desired minerals are relatively free from attached pieces of waste. The material is then ready for the separation step.

The separation processes are developed to take advantage of the specific properties to be won. These may include physical, chemical, or electrical properties, and combinations thereof. By and large, we are concerned in the mining industry with substantial tonnages which require cheap handling of large bulk volumes of solids. This implies the economical distribution and control of large blocks of electric power. But as large as these present-day installations are, the future demands of electric power promise to be much greater.

The major development on the horizon will be the beneficiation of large tonnages of hard, compact, iron-bearing rock in the Upper Lakes Region to provide the essential raw materials in the steel industry in the form of concentrated iron minerals. This will require that from two to three times as much tonnage be mined, and beneficiated, as that now required for the same pig iron production. Beneficiation on the Minnesota iron ranges is not new. This was inaugurated 40 years ago by the United States Steel Corporation in a pilot plant which was replaced by a large commercial installation in 1910 which is still in operation. Many other plants were built by the industry, and a substantial annual tonnage continues to flow from this source. This is expanding in volume and will continue for many years in the future.

As the applications of ore beneficiation expand, the Upper Lakes Region will assume its place as one of the major beneficiation centers of the world. Several types of processes will be used, but in any case, large increases in power requirements are indicated, and the ultimate success of this important development will depend to a considerable extent on the satisfactory solution of electrical engineering problems.

Electric Truck Control Systems; *T. O. English (Aluminum Company of America, Pittsburgh, Pa.).*

The cost of operating electric trucks may be broken down into six general categories, as follows:

1. Cost of tires.
2. Fixed charges of batteries.
3. Maintenance cost of batteries.
4. Cost of power.
5. Fixed charges against truck proper.
6. Mechanical and electrical maintenance of truck proper.

As the first five categories generally are fixed, it is with the sixth, that is, mechanical and electrical maintenance of truck proper, that the paper deals. Of prime importance is the matter of proper interlocking so that excessive stresses may not be exerted on the electric and mechanical equipment. Although there are several methods that could be used to provide "foolproof interlocking," control systems on trucks, standard models, in general, are not offered with such interlocking devices.

Associated somewhat with interlocking is also the matter of proper control to provide adequate acceleration and deceleration of electric trucks. Control providing full automatic, true nonplugging acceleration on a fixed time or predetermined current basis generally is not available and the basic equipment for operation at the proper voltage and current generally has not been designed.

On those applications where an attempt has been made to apply full magnetic control, it has been necessary to use equipment that normally would be used for much higher voltages and, therefore, it is too large and cumbersome for the space that is available.

The method of braking, as well as the method of applying the brakes to electric trucks in general, has not been good. Under standard practice, the operator is expected to stand on one foot, at times out of balance, and do a good job of applying brakes as well as steering and controlling the truck. Power steer in the larger sizes of trucks is a distinct advancement. In many instances, however, power steer has a tendency to hunt and it has been troublesome. What to some might be a revolutionary idea is the possibility of combining steer and control into one "joy stick" controller which would handle steering by sidewise motion and speed by operating it forward and reverse. Braking could be provided by pushbutton in the handle of the "joy stick" or, if desired, by a separate lever to be used by the other hand. In summation, the following specific improvements are recommended:

(*a*). Control should be fully magnetic with automatic time acceleration and nonplugging in fact.

(*b*). Brakes should be on driving wheels instead of on motor shaft.

(*c*). Braking energy should not be provided directly by the operator, permitting the control of the brakes to be from a push-button in the controller handle, or something equivalent.

(*d*). Provide improved automatic steering, and if possible, provide a single control for all of the operator's functions.

Induction Heating; *W. C. Rudd (Induction Heating Corporation, Brooklyn, N. Y.).*

Induction heating is now an established industrial tool that speeds up production heating, and also accomplishes results that cannot be achieved in any other way. Induction heating can be used for two forms of localized heating of conducting materials. The first form, surface heating, is governed by the rate of energy input as well as the thermal conductivity of the material. The second type is the heating of sections or a band on a piece of work. Here greater tolerance of heat flow may be necessary because deeper heating may be required for jobs such as brazing. Induction heating also can be used for thorough heating a metal by utilizing the natural thermal conductivity of the material. In this case, the rate of energy transfer must be low in order to prevent overheating of the surface. High power can be used if more area of material is heated at one time.

A new type of heating which is not strictly induction heating, but utilizes high-frequency currents, has been used recently. This new method is called proximity heating, and involves the passage of a high-frequency current through a piece of work in a path controlled by the proximity of the return conductor.

This is a variety of resistance heating, but produces effects similar to induction heating. The magnetic and physical characteristics of a material govern its ability to be heated by induction heating. A magnetic material increases the magnetic flux density and, therefore, results in a higher heating rate due to the corresponding increase in induced current. Materials heated above their Curie point act as non-magnetic materials. The resistivity of the material governs the amount of I^2R heat that is produced in the work in the same manner that it governs the heat produced in resistance heating.

The thermal conductivity of a material governs the rate at which energy can be distributed within the work. It is very difficult to surface heat copper due to its high thermal conductivity, but it is easy to surface-heat magnetic steel which has a much lower thermal conductivity. Radiation from the work is governed by the surface and the surrounding media. This can be reduced by insulation or reflecting devices.

Our 1948–49 AIEE Budget

—*A Message From the President*

Every electrical engineer likes a balanced budget, and the 1948–49 AIEE budget approved by the board of directors, October 19, 1948, is a balanced budget, as follows:

Estimated income, 1948–49—$775,000
Estimated expenditures, 1948–49—$769,465

It is a tribute to our Institute that there has been no dues increase since 1925, and in all of the years since, except for two or three depression years, we have operated with a balanced budget and have put appropriate sums into reserve, until the past two years, when our expenditures have exceeded our income.

For 1947–48 our expenditures were $716,-270 and our income $684,453—we thus face in the current years the task of increasing our income and reducing our expenditures without curtailing our activities too drastically. This, we have done in the budget.

Our largest item of expense is for publications—a total of $273,590. *ELECTRICAL ENGINEERING* is the greatest expense, $177,615 for 1,200 pages. We have reduced the pages from 1,335 for the past year. The cost of the 1,200 pages for the coming year will be even more than the cost for the 1,335 pages last year.

Our *TRANSACTIONS* which give a permanent record of the papers presented before the Institute, our outstanding contribution to our fellowmen, cost us $20,200 beyond their base cost. We receive in return subscriptions to the amount of $9,000. The subscription price has been increased from $4 to $5 per volume.

The *PROCEEDINGS* available to members on a request basis this year will cost $32,375, to provide for an increase to 250 papers comprising 1,750 pages from 225 papers comprising 2,020 pages last year. Preprints of technical papers will cost $25,-000; our return will be $20,000 at an increased price. Advertising will cost us $96,400; the return will be $180,000. The "Year Book" costs $12,000; it is free upon request. It allows those in the immediate work of the Institute to have necessary material for the progress of the work. We feel the substantial position of our expenditures for publication of our technical papers and timely articles of interest is well justified. The value of *ELECTRICAL ENGINEERING* alone is more than the dues of a large portion of our membership.

In addition, come many projects of value to our members. The cost of District and general meetings is $30,200; we have this year instituted a registration fee at District and general meetings to return $19,000 of this. It is our feeling that those who participate directly in these meetings well can afford to carry this portion of the load to their advantage.

To our Sections we return $72,550 for the progression of their activities. Here is the Institute membership at its work. To the Students in their Branches, we return $5,950. Here are the Students at work.

The committees will spend $61,050. The largest portion is for Standards, $24,800 which is our contribution to the facilitation of trade. To our technical committees we give $12,000. This is only a small portion of the total cost, the remainder of which is borne by industry. For our membership committee we allow $18,000 that our membership will continue to expand and to be representative. To all other committees we give $6,250.

For traveling we provide $50,950. This assures our officers, directors, District officers, Student Branch officers, Section officers, the necessary travel expense for carrying out their duties—this is one of the great strengths of our Institute.

For joint activities with other engineering societies we will spend $40,105. The largest item is to United Engineering Trustees for our Engineering Societies Building Headquarters in New York, N. Y., $19,550. For the Engineering Societies Library, $15,600, that the best and most specialized of engineering literature will be available to all. For all others the amount is $4,955.

For prizes for the best of Institute and Student Branch papers, $2,650.

Then there is a group of items, all administrative: badges, $6,000; rental of editorial headquarters at 500 Fifth Avenue, New York, N. Y., $7,000; for pensions for our staff members, $8,000; for miscellaneous sales printing, $13,000; for paper, $10,000; for additions to our staff to care for our expanding membership and activities, $12,-000; and for salary increases, $8,000, together with expenditures for administration which cannot be directly allocated.

Everett S. Lee

This gives a total of $769,465, a goodly sum.

This money comes from:

Membership dues	$396,000
Student dues	40,000
Entrance and transfer fees	23,000
Advertising	180,000
Subscriptions to *ELECTRICAL ENGINEERING*	30,000
Subscriptions to *TRANSACTIONS*	9,000
Interest on investments	21,000
Publication sales	57,000
Registration fees	19,000
Total	$775,000

So while we may not put any money in the bank this year, we will, through these efficiencies and economies and more direct allocation of expense, at least break even. And we will not have to increase dues yet.

A Merry Christmas to all.

High-Frequency Measurements to Be Subject of Conference

A conference on high-frequency measurements sponsored jointly by the AIEE, the Institute of Radio Engineers, and the National Bureau of Standards will be held in Washington, D. C., on January 10, 11, and 12, 1949. The purpose of the symposium is to bring together those interested in high-frequency measurements and measuring apparatus at a meeting which will be devoted solely to these topics. To this end, the technical program consisting of four sessions over a 3-day period has been planned to include surveys of various branches of the art, and the presentation of the latest developments in measuring technique. A very excellent technical program has been arranged.

Washington was chosen as the location for the symposium largely on the basis of the presence of the various government laboratories and the great interest in the subject in that area. Registration and general headquarters will be at the Roger Smith Hotel. All of the technical sessions will be held at the Department of Interior auditorium. A registration fee of $2 will be charged those attending the conference for purpose of defraying the expenses.

In addition to the technical sessions, tours have been arranged to the Naval Research Laboratory, the Naval Ordnance Laboratory, and the National Bureau of Standards. A luncheon is planned at the Roger Smith Hotel for Tuesday, January 11.

This conference is the first to be held on a national basis devoted solely to the topic of high-frequency measurements. It is in line with the present AIEE policy of sponsoring conferences to cover a single field and is expected to attract a large attendance.

Record Attendance Foreseen for 1949 Winter Meeting

It is anticipated that attendance at the AIEE winter general meeting, which will be held in New York, N. Y., during the week of January 31 through February 4, 1949, will be the largest in the history of the Institute. A new departure in Institute practice will occur this year in that the meeting headquarters and all activities including the technical sessions will be held at a convention hotel. This change from the Engineering Societies Building to the Pennsylvania Hotel has been made to provide more adequate meeting space and facilities for staging the extensive program now in the course of development. The choice of the Pennsylvania Hotel also will prove advantageous to those out-of-town members who use the Pennsylvania Railroad, as the Pennsylvania Station is adjacent to the headquarters hotel and connected to it by means of an underground passageway.

The technical committees have shown wide interest in the program for this winter general meeting, as evidenced by the large number of technical sessions requested. A meeting of the technical program committee was held Friday, October 29, 1948, at which time the number of sessions to be scheduled was decided upon. The complete list of sessions for the winter general meeting will appear in the January issue.

The highlights of the evening entertainment program will be the dinner-dance at the Pennsylvania Hotel on Tuesday, February 1,

Winter Meeting Dinner-Dance

After a lapse of two years, the dinner-dance, most important social event of the winter general meeting, will be resumed this year. It will be held on the evening of February 1, 1949, in the main ballroom of the Hotel Pennsylvania, center of activities for the meeting. Difficulties in making hotel arrangements have made it necessary to interchange the nights traditionally assigned to the dinner-dance and the smoker, so that the dinner-dance will be held on Tuesday evening of winter meeting week, and the smoker on Thursday evening.

Plan to attend the dinner-dance and meet all your friends. Reserve a table for your own party and enjoy an evening of good food, good conversation, good music, and dancing. Tickets are $11 per person. Make checks payable to "Special Account, Secretary AIEE," and send to AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Tentative Program

Conference on High-Frequency Measurements, Washington, D. C.

Monday, January 10

9:30 a.m. Registration—Roger Smith Hotel

9:30 a.m. Tour of National Bureau of Standards

1:30 p.m. Technical Session—Measurement of Frequency

Chairman: E. I. Green

Microwave Spectroscopic Frequency and Time Standards and Measurements. *Harold Lyons*, National Bureau of Standards

Frequency Stabilization With Microwave Spectral Lines. *W. D. Hershberger*, RCA Laboratories

Stabilization of Microwave Oscillators. *E. W. Fletcher*, Harvard University

Superconducting Resonant Cavities—Measurements of the Surface Impedance of Normal and Superconductors at Low Temperatures and Microwave Frequencies. *E. Maxwell*, National Bureau of Standards

A Stabilized Variable-Frequency Oscillator for Precision Frequency Measurements. *L. F. Koerner*, Bell Telephone Laboratories, Inc.

The Measurement of Frequency n the Millimeter Bands. *John B. Hagen*

Tuesday, January 11

9:30 a.m. Technical Session—Measurement of Power and Attenuation

Chairman: F. J. Gaffney

Power Sources for Microwave Measurements. *G. Hackley*, Sperry Gyroscope Company

Bolometric Measurement of Microwave Power Over Broad Frequency Bands. *Doctor Herbert J. Carlin*, Microwave Research Institute

Microwave Metallized-Glass Attenuators. *Doctor John W. E. Griemsmann*, Microwave Research Institute

A Method for Measuring the Effective Conductivity of Wires at Microwave Frequencies. *A. C. Beck, R. W. Dawson*, Bell Telephone Laboratories, Inc.

X-Band Phase Shiftless Power Splitter. *H. J. Riblet*, Submarine Signal Company

A Figure of Merit for Directional Couplers. *G. James*, Sperry Gyroscope Company

12:30 p.m. Luncheon, Roger Smith Hotel

2:15 p.m. Tours to Naval Research Laboratory, Naval Ordnance Laboratory, and National Bureau of Standards

Buses will leave from Roger Smith Hotel

Wednesday, January 12

9:30 a.m. Technical Session—Measurement of Impedance

Chairman: Hugh Webber

A Precise Direct Reading Phase and Transmission Measuring System for Video Frequencies. *D. A. Alsberg, D. Leed*, Bell Telephone Laboratories, Inc.

Methods of Measuring Impedance and Voltage Standing Wave Ratio at Microwave Frequencies. *F. Klawsnik*, Sperry Gyroscope Company

Generator Mismatch Measurement in Transmission Lines. *P. E. Gilmer*, Bell Telephone Laboratories, Inc.

A Method of Measuring Phase at Microwave Frequencies. *Sloan D. Robertson*, Bell Telephone Laboratories, Inc.

Dielectric Measurement Techniques in the Ultrahigh-Frequency Region. *W. B. Westphal*, Laboratory for Insulation Research, Massachusetts Institute of Technology

A Null Type of Impedance Measuring Device in the Ultrahigh-Frequency Range. *J. F. Byrne*, Airborne Instruments Laboratory

Measurement of the Electrical Characteristics of Quartz-Crystal Units by Use of a Bridged Tee Network. *Charles H. Rothauge*, The Johns Hopkins University

2:30 p.m. Technical Session—Measurement of Noise, Antenna Measurements

Chairman: H. A. Wheeler

Reduction of Cable Reflections in Antenna Pattern Measurements. *E. Fubini*, Airborne Instruments Laboratory

Program of Instrumentation for Antenna Measurements. *L. C. Van Atta, O. A. Tyson*, Naval Research Laboratory

Measurement of Artificial Dielectrics for Microwave. *W. E. Kock*, Bell Telephone Laboratories, Inc.

Microwave Noise Sources. *I. Mirman, J. H. Vogelman*, Watson Laboratories; *Professor R. H. George*, Purdue University

Measurement of Noise Interference Caused by Radar Equipments. *J. R. Logie, Jr.*, Bell Telephone Laboratories, Inc.

Transmission Line Method for Measuring Sensitivity of Receivers With Loop Antennas. *C. E. Kilgour*, Crosley Radio Corporation.

and the smoker at the Commodore Hotel on Thursday, February 3. The price of the tickets for the dinner-dance has been set at $11 per person. An extensive program for the entertainment of the women attending is being organized under the direction of the ladies' entertainment committee. For the convenience of out-of-town members, blocks of theater tickets for popular shows will be available for sale in advance of the meeting. Tickets for broadcasts also will be provided.

To help defray part of the expenses incurred by the Institute in the holding of meetings, the AIEE board of directors has decided that registration fees shall be collected from members and nonmembers. For members, the fee will be $3; for nonmembers, $5. As it is believed most of those attending the meeting will want to be located in the headquarters hotel, the Pennsylvania Hotel has agreed to set aside a large number of rooms for those attending the meeting.

Middle Eastern District Meeting Held in Washington, D.C., October 5–7

A highly successful Middle Eastern District meeting was held in Washington, D. C., October 5–7, 1948, which broke all attendance records for Middle Eastern District meetings. Some 715 people attended the 20 technical sessions of the 3-day meeting where 50 technical program papers and conference-type papers were presented. The tables show an analysis of the attendance at the meeting.

An unusually large number of papers (for a District meeting) covering a range of subjects from air transportation to nuclear engineering and government relations made for an interesting meeting. One-page digests of some of the technical program papers appear in this issue (see "Highlights" section for a listing of these papers), and others are scheduled for forthcoming issues of *ELECTRICAL ENGINEERING*. Short digests of the conference papers presented appear elsewhere in this issue (*pages 1194-9*).

The executive committee of District 2 held its meeting on Monday, October 4, 1948, the day before the Middle Eastern District meeting began. A number of items pertaining to District 2 business were discussed. A report on this meeting appears in this issue (*page 1210*).

The meeting's first event was a general session presided over by Fischer S. Black, editor of *Electrical World*, and general chairman of the meeting. He introduced AIEE Secretary H. H. Henline, AIEE Past-President C. A. Powel, and AIEE President Everett S. Lee.

President Lee congratulated the meeting committee on its fine work, and commented on his visits to the various Sections of the Institute where he noted the splendid activities reflecting the work of the AIEE throughout the country.

Doctor William McClellan (AIEE past-president and honorary chairman of the meeting) introduced the main speaker of the morning, Doctor F. B. Silsbee, chief of the division of electricity and optics at the National Bureau of Standards, Washington, D. C. Doctor E. U. Condon, director of the National Bureau of Standards, who was to have been the main speaker of the morning was in Paris attending the International Congress of Weights and Measurements and could not be present. His place was taken by Doctor Silsbee.

The close relationship that has been maintained between AIEE and the National Bureau of Standards through the years was cited by Doctor Silsbee. His talk also covered the work of the bureau in setting up standards of measurement. Colored slides of equipments used to perform basic measurements such as resistance, inductance, and capacitance illustrated his talk.

Student activities were the subject of discussion at a luncheon held at the George Washington University faculty club on Tuesday. The gathering was presided over by Professor J. L. Beaver, chairman of District 2 committee on Student activities, and was attended by AIEE President Lee. Among the questions raised at this luncheon meeting were those concerning the feasibility of operating joint AIEE-IRE (Institute of Radio Engineers) Student Branches in the various colleges throughout the country. President Lee mentioned that the bylaws of AIEE provide for Student Branches and also for joint association with other national engineering societies approved by the board of directors. H. N. Miller, Jr. (chairman of the AIEE committee on Student Branches) and Doctor W. H. Radford (of Massachusetts Institute of Technology, representing the Institute of Radio Engineers) are studying details to devise a workable plan for joint AIEE-IRE Student Branches.

An informal panel-type discussion was held at a breakfast meeting Thursday morning. The panel members included G. W. Bower (vice-president, District 2), R. D. Bennett (chairman of the Washington Section), F. S. Black (general chairman of the Middle Eastern District meeting committee), AIEE Past-President C. A. Powel, and AIEE President E. S. Lee. A number of members attended this gathering during which such questions as Institute dues, professional recognition, and better Section meetings were discussed.

Entertainment features of the meeting included a smoker which was held Tuesday evening and the dinner-dance held Wednesday evening. A number of well-attended inspection trips to many points of interest were held during the meeting. These included the David Taylor Model Basin, the Carnegie Institution of Washington, Washington National Airport, and the National Bureau of Standards. For the women there were sight-seeing trips to Mt. Vernon and one around Washington.

Two joint technical sessions were held during the meeting. The first was one on illumination, held jointly with the Illuminating Engineering Society, with C. S. Woodside presiding. Four conference-type papers on various aspects of illumination were presented. The other joint session was one on

The speakers' table at the opening session of the AIEE Middle Eastern District meeting showing (left to right) Fischer S. Black, general chairman of the meeting committee, opening the session; Doctor F. S. Silsbee, of the National Bureau of Standards, who was the main speaker of the morning; AIEE President E. S. Lee; Doctor William McClellan, honorary chairman of the meeting committee; C. A. Powel, AIEE past president; and H. H. Henline, AIEE secretary

communication held jointly with the American section of URSI (the International Scientific Radio Union) and the Institute of Radio Engineers. Four conference-type papers were presented on topics including radio relay, television, radar, and electronic heating.

This was the second Middle Eastern District meeting to be held in Washington, D. C. The first one was held there in 1925 when the District meeting first was instituted in the Middle Eastern District. That it was a success is indicated by the large attendance and the spirited discussions that took place during the various sessions. The success of the meeting was made possible through the efforts of the meeting committee which included the following personnel:

Middle Eastern District Meeting Attendance 1925–1948

Date	Location	Attendance
1948—Oct. 5–7	Washington, D. C.	715
1947—Sept. 23–25	Dayton, Ohio	502
1940—Oct. 9–11	Cincinnati, Ohio	599
1939—Oct. 11–13	Scranton, Pa.	313
1937—Oct. 13–15	Akron, Ohio	464
1932—Oct. 10–13	Baltimore, Md.	240
1931—Mar. 11–13	Pittsburgh, Pa.	500
1930—Oct. 13–15	Philadelphia, Pa.	500
1939—Mar. 20–23	Cincinnati, Ohio	270
1928—Apr. 17–20	Baltimore, Md.	400
1927—Apr. 21–23	Bethlehem, Pa.	400
1926—Mar. 18–19	Cleveland, Ohio	430
1925—Jan. 23–24	Washington, D. C.	212

William McClellan, *honorary chairman;* Fisher S. Black, *general chairman;* W. F. Dietz, *arrangements;* D. K. Steidinger, *secretary-treasurer;* D. S. Bender, *technical meetings;* J. S. Antel, *Students;* R. D. Bennett, *special meetings;* L. H. Cleary, *finance;* I. F. Conrad, *publicity;* F. B. Crider, *smoker;* C. H. Giroux, *sports;* Mrs. W. J. Lank, *ladies;* W. J. Lank, *entertainment;* Dixon Lewis, *dinner;* J. O. Pease, *registration;* G. R. Wilhelm, *inspection trips.*

Middle Eastern District Awards Best Paper Prizes

Twenty-three eligible papers were submitted by the Sections in District 2 (Middle Eastern) for the 1947 District 2 prize paper competition. To be eligible for entry in the competition, the paper must have been presented within District 2 during 1947 by a member residing in that District. Nine of these papers were eligible for the District prize for best initial paper. The District co-ordinating committee appointed as judges: A. J. B. Fairburn, A. H. Forman (unable to serve), W. C. Harris, E. E. Kimberly, H. L. Prescott, H. J. Talley, and L. A. Doggett, chairman.

The District best paper prize was awarded for a paper on "Performance Criteria of D-C Interrupters" by E. W. Boehne and M. J. Jang. The District best initial paper prize was tied, and finally was awarded to two papers: "Attenuation Instability of Flexible Coaxial Cable in the Microwave Region," by M. C. Biskeborn, and "Machine Computation of Power Network Performance," by L. A. Dunstan. Certificates of award and checks for prize money ($12.50 each), were awarded to the four prize winners at a dinner meeting, held during the District executive committee meeting in Washington, D. C., October 6, 1948.

Nineteen of the 23 Student Branches in District 2 held Branch contests. The winner of each Branch contest received a certificate of award, a cash prize of $10 and a travel allowance of 7 cents per mile one way to attend the District Branch prize paper competition, which was held at Ohio State University, Columbus, Ohio, May 14 and 15, 1948 (*EE, Jul '48, pp 711–12*). Seventeen of the Branch contest winners presented their papers at Columbus, Ohio. The judges appointed by the District co-ordinating committee were: A. J. B. Fairburn (chairman), R. C. McMaster, W. C. Osterbrock (unable to serve), A. F. Puchstein, and H. R. Weed. The winner of this competition was John N. Grace of Carnegie Institute of Technology for his paper on "Electroencephalography." Mr. Grace received travel allowance and reasonable expenses, financed by the Member-for-Life Fund, to go to the summer general meeting in Mexico City in June 1948 where he presented an abstract of his paper. A certificate of award and a cash prize of $25 was awarded to Mr. Grace at a dinner meeting, held during the District executive committee meeting in Washington, D. C.

The District 2 executive committee at its meeting in Washington, D. C., October 4, 1948, considered the Institute prize paper rules which became effective January 1, 1948, and which eliminated cash prizes for District prize paper competitions, and provides for certificates only to be issued by headquarters. By unanimous vote, the District executive committee decided to continue District prize paper competitions in District 2, with cash prizes to be financed by payments from each Section, these payments to be subject to confirmation by the executive committees of the individual Sections.

Analysis of Registration at Washington, D. C.

Classification	Washington Section	District 2*	Other Districts	Total
Members	225	142	81	448
Student Members	18	6	4	28
Men guests	72	42	32	146
Women guests	56	28	9	93
Totals	371	218	126	715

* Outside Washington Section.

At the close of technical session on marine transportation held during the AIEE Middle Eastern District meeting, R. A. Beekman, manager of the aircraft, federal, and marine divisions of General Electric Company, Schenectady, N. Y., was nominated a Fellow of the Institute. Shown here is R. A. Beekman (second from left) being congratulated by W. H. Fifer, Bureau of Ships, United States Navy; Captain R. E. Cronin, Bureau of Ships, United States Navy; and AIEE President E. S. Lee

AIEE Proceedings

Order forms for current AIEE *PROCEEDINGS* have been published in *ELECTRICAL ENGINEERING* as listed below. Each section of AIEE *PROCEEDINGS* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *TRANSACTIONS*.

AIEE *PROCEEDINGS* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*). They are available to AIEE Student Members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *PROCEEDINGS* will appear in *ELECTRICAL ENGINEERING* in abbreviated form.

Location of Order Forms	Meetings Covered
Apr '48, p 49A	Winter general
Aug '48, p 45A	Great Lakes District North Eastern District Summer general
Oct '48 p 43A	Pacific general Middle Eastern District
Dec '48, p 35A	Midwest general Southern District

District 2 Executive Committee Holds Meeting in Washington, D. C.

The District executive committee meeting, AIEE Middle Eastern District (2), was held in the Capitol Room of the Statler Hotel, Washington, D. C., Monday, October 4, 1948, 10:00 a.m. to 5:00 p.m. Discussions were of the conference type, giving all members present the opportunity to participate actively. The morning session included conferences on Section-Branch co-operation and Student activities, membership activities, and District prize paper competition. Lunch was held in the Pan American Room. The afternoon session included various items of business, and a conference on Section operation and management. This meeting was on October 4, to give the members of the District executive committee the opportunity to attend the Middle Eastern District meeting in Washington, on October 5 to 7, 1948.

Professor J. L. Beaver, chairman for 1947–48 of the District 2 committee on Student activities, led the conference on Section-Branch co-operation and Student activities. The important points brought out by the conference were

1. Every Section should have a Student activities committee.

2. Student members should receive notices of all Section meetings. This is accomplished by many Sections by mailing the notices in bulk to the Student counselor, who distributes the notices to the Students. In some localities where technical councils are established, notices of all technical meetings, including the AIEE meetings, are sent to the Students.

3. Many Sections have a "father and son" night, at which the Section members are host to Students, paying for their dinner, discussing their problems with them, and seeing that they have a sociable evening.

4. While some Sections may not have Student Branches in their territory, they may have many Student members who have come to work for manufacturing concerns. The Section should keep in touch with these Student members.

5. Many Sections in District 2 contributed to the support of the District 2 "Student News Letter" activity. The Students plan to continue the "News Letter" this year, and the Sections will be asked for contributions.

District Secretary Muir gave a brief review of the 1947–48 District 2 prize paper competitions for members and Student members. The Sections in District 2 entered 23 papers in the District prize paper competition for the calendar year ending 1947. The District prize for best paper was awarded to E. W. Boehne and M. J. Jang for their paper, "Performance Criteria of D-C Interrupters." While the District prize for best initial paper was awarded to M. C. Biskeborn and L. A. Dunstan for their papers, which were tied for first prize, "Attenuation Instability of Flexible Coaxial Cable in the Microwave Region," and "Machine Computation of Power Network Performance."

Nineteen of the 23 Student Branches in District 2 held Branch prize paper competitions. Seventeen of the Branch contest winners presented their papers at Columbus, Ohio, May 14 and 15, 1948, at the District Branch Prize Paper Competition. John N. Grace, Carnegie Institute of Technology, won the first prize for his paper, "Electroencephalography."

For further details on these two prize paper competitions, see the item on District 2 prize papers (*page 1209*).

Vice-President Bower pointed out that the Institute prize paper rules, which became effective January 1, 1948, eliminated cash prizes for District prize paper competitions, but authorized the issuance of certificates by headquarters. After considerable discussion, by unanimous vote, the District executive committee decided to continue District prize paper competitions, to be financed by payments of at least $3 by each Section in District 2, this to be subject to confirmation by the executive committees of the individual Sections.

F. H. Knapp, District 2 vice-chairman, AIEE membership committee, led the conference on membership activities. He pointed out that the net gain in AIEE membership for the last year was only 7.25 per cent compared with 8.5 per cent. Also, that for each net gain of one member, the Institute must receive 1.95 new applications. The membership at present is approximately 28,500.

The following important points on membership activity were brought out:

1. The Sections should have a worthwhile program to attract new members, and should give their members the opportunity to participate in Section activities.

2. A large diversified membership committee is needed, with members distributed within the various industries in the Section territory.

3. The membership committee should have a planned list of prospects.

4. The attendance and hospitality committees have very important functions in getting new members to meetings and seeing that they are introduced to other members.

5. Engineering students are the greatest source of prospects for membership in AIEE.

6. AIEE members should keep the membership committee posted on engineering graduates who have taken a job with their company.

7. Subsections provide an opportunity for members in remote areas to participate in Section activities, and thereby attract many new members.

8. The transfers committee should work to up-grade members to the status to which they are eligible.

The District executive committee nominated for the office of vice-president for District 2 for the 2-year term beginning August 1, 1949, C. G. Veinott of the Dayton Section. He is special development engineer of the Westinghouse Electric Corporation, Lima, Ohio.

J. C. Strasbourger was appointed as District 2 member to the Institute nominating committee. He was instructed to support J. F. Fairman for the office of Institute president for the one-year term beginning August 1, 1949, as long as Mr. Fairman has a chance to win.

A motion was passed that the District 2 member of the Institute nominating committee go uninstructed of the nomination of the three directors for the 4-year term beginning August 1, 1949, but to go conscious of the fact that Institute activities spring from the Sections and that Institute directors should be Section-minded. The representative was asked to investigate all of the candidates for Institute director.

H. A. Dambly, Section committee representative to District 2 executive committee, led the discussion on Section operation and management. Mr. Bower pointed out that the total attendance at Section meetings last year fell 35,600 below the previous year's of 155,600, and that it is up to the Section officers to make their programs good enough to attract attendance. Many Sections find that attendance at technical meetings and technical groups exceed the attendance at general interest meetings. Meetings with a "big name" speaker usually attract large attendance. Subsections and technical groups have been found to be very helpful in getting new members and in holding present members. Some Sections have local members who pay local dues, and participate only in local activities. Lapel cards are used at meetings for attendance records, and cards of guests are turned over to the membership committee as prospects. Student activities is a very important feature of most Sections. Generally speaking, the attendance at meetings of most of the Sections in District 2 has increased during the last year, which was the reverse of the trend in the Institute.

Inspection trips again have become a very important part of the programs of the Sections, and Student prize paper night is an established feature of several Sections. Many Sections have a brief talk by a member of the local Section before the main speaker of the evening. One Section found that an "electronics" technical group was attended mostly by Institute of Radio Engineers members and did not attract AIEE members, but that a technical group on "industrial electronics" would have been highly successful in attracting AIEE members. Another Section believes that too many AIEE members know too little about AIEE. Fifteen or 20 minutes at each Section meeting is used to inform members about various activities of AIEE, local and national.

Mr. Bower described briefly the technical conference on electrical applications in the rubber and plastics industry, held in Akron, Ohio, and the conference on electron tubes, held in Philadelphia, Pa.

There was a general discussion of the membership of the District executive committee, and the desirability for having permission for alternates to attend District executive committee meetings, as well as having a third member from each Section attend the District executive committee meeting. A motion was passed by unanimous vote that:

The District secretary address a letter to the board of directors, the members of the finance committee, and the Sections committee, telling of discontent in regard to past action prohibiting alternates and eliminating the third representative to the District executive committee meetings, and pointing out the desirability of continuity in attendance at these meetings.

The Institute travel allowance was discussed, and a motion was passed that:

Inasmuch as in District 2, the 11 cents per mile travel allowance fails to cover the railway fare, we recommend that the finance committee provide an adequate adjustment in the present travel allowance.

AIEE Board of Directors Holds Meeting in Milwaukee

A regular meeting of the AIEE board of directors was held at the University Club, Milwaukee, Wis., October 19, 1948, during the Midwest general meeting in that city.

President Lee reported briefly on visits made by him, including the Pacific general meeting, inaugural meeting of the Richland and Niagara Falls Sections, and other Sec-

tions and Branches in the northwestern and southeastern parts of the country; and Vice-Presidents Bower, Callahan, and Siegfried reported briefly on several functions at which they had been designated to represent the Institute. It was reported that Doctor W. B. Kouwenhoven would represent the Institute at a meeting of the National Research Council, Washington, November 10.

The minutes of the meeting of the board of directors held on August 5, 1948, were approved.

MEMBERSHIP ACTIONS

The following actions of the executive committee by letter ballot, as of September 23, 1948, were reported and confirmed: 13 applicants transferred to grade of Fellow and one Fellow reinstated; 69 applicants transferred to grade of Member and four Members re-elected; 162 applicants elected to grade of Associate and one Associate reinstated; 248 Student members enrolled.

Recommendations adopted by the board of examiners at meetings held on September 16 and 30, 1948, were reported and approved. The following actions were taken upon recommendation of the board of examiners: 13 applicants were transferred to the grade of Fellow; 59 applicants were transferred and 54 were elected to the grade of Member; 88 applicants were elected to the grade of Associate; 623 Student members were enrolled.

FINANCES

Disbursements from general funds in three months were reported and approved as follows: August 1948, $55,404.27; September 1948, $57,969.10; October 1948, $72,-576.91.

Upon recommendation of the finance committee, the board voted to continue for another year the present exchange allowance of up to 40 per cent on dues payments by members in countries affected by unfavorable exchange rates.

A budget for the appropriation year beginning October 1, 1948, was adopted as submitted by the finance committee and revised at the board meeting.

President Lee reported that it had been impossible to arrange to have the Institute represented directly at the Engineering Societies Conference in London, England, early in October and that he had requested W. K. Brasher, Secretary of The Institution of Electrical Engineers, to inform the conference regarding relations between the two organizations and to supply the AIEE with information regarding conclusions reached. He had received from Mr. Brasher an advance copy of the conclusions adopted, and a statement that a more complete record will be transmitted later.

President Lee reported that, under the action taken by the board of directors on August 5, he had appointed Chairman H. N. Muller, Jr., of the committee on Student Branches to confer with Doctor Radford of Massachusetts Institute of Technology, who had been appointed by President Shackelford of Institute of Radio Engineers, "in an effort to work out an operating procedure for joint AIEE-IRE Student Branches, for recommendation to the board of directors."

Upon recommendation of the committee on planning and co-ordination, the directors approved the dates of April 26–28, 1950, for the North Eastern District meeting previously authorized to be held in Providence, R. I., in that year, and authorized holding the 1952 summer general meeting in Minneapolis-St. Paul, Minn., June 23–27.

Members of the board of directors were selected to serve as representatives on the nominating committee, and as alternates, as follows: *Representatives:* J. H. Berry, G. W. Bower, C. W. Fick, Victor Siegfried, Walter C. Smith; *alternates:* J. L. Callahan, M. D. Hooven.

AMENDMENTS

The following amendments to the bylaws were adopted, upon recommendation of the committee on constitution and bylaws:

The first sentence of section 105 (section 107 in revised edition of bylaws in the 1948 Year Book) was amended by the deletion of the words "but not to exceed $5 per year," the sentence to read: "The *TRANSACTIONS* shall be available to members and to nonmember subscribers to *ELECTRICAL ENGINEERING*, upon advance subscription at prices fixed by the publication committee."

Sections 67, 69, 71, 72, 75, 81, 84, and the new section on committee on transfers were amended by the addition in each case of the following sentence: "At least one member of the committee shall be a member of the board of directors." (In the 1948 Year Book, these sections have the numbers 66, 77, 82, 69, 74, 81, 80, and 86 respectively.)

The board of directors approved proposed amendments to the bylaws of United Engineering Trustees, Inc., governing the personnel of the Library board, to effect simplification of operation and involving a reduction in number of members of that board from 22 to 12.

Upon recommendation of the committee on planning and co-ordination and the committee on Institute publicity, the name of the latter committee was changed to committee on public relations.

Action was taken authorizing the regular traveling expense allowance for an alternate for a Section chairman or secretary unable to attend a District executive committee meeting, with the written approval of the vice-president. As alternates are not members of the District executive committees, it was agreed that the committee on constitution and bylaws will study the matter of their voting at District executive committee meetings.

The board of directors voted to adopt a plan for encouraging Student members to apply upon graduation for admission as Associates, which was adopted by the committee on Student Branches at its meeting in Mexico, Federal District, Mexico, on June 22, 1948; and the secretary was requested to notify the Branch counselors regarding this action. Other matters were discussed, reference to which may be found in this or future issues of *ELECTRICAL ENGINEERING*.

ATTENDANCE

Present at the meeting were

President—Everett S. Lee, Schenectady, N. Y.

Past President—J. Elmer Housley, Alcoa, Tenn.

Vice-Presidents—J. H. Berry, Norfolk, Va.; G. W. Bower, Haddonfield, N. J.; John L. Callahan, New York, N. Y.; D. I. Cone, San Francisco, Calif.; I. M. Ellestad, Omaha, Nebr.; D. G. Geiger, Toronto, Ontario, Canada; Richard McKay, Spokane, Wash.; G. N. Pingree, Dallas, Tex.; Victor Siegfried, Worcester, Mass.; Ira A. Terry, Fort Wayne, Ind.

Directors—W. L. Everitt, Urbana, Ill.; J. F. Fairman, New York, N. Y.; C. W. Fick, Cleveland, Ohio; R. T. Henry, Buffalo, N. Y.; M. D. Hooven, Newark, N. J.; F. O. McMillan, Corvallis, Oreg.; Elgin B. Robertson, Dallas, Tex.; Walter C. Smith, Palo Alto, Calif.; E. P. Yerkes, Philadelphia, Pa.

Secretary—H. H. Henline, New York, N. Y.

Highly Successful Midwest Meeting Held in Milwaukee, October 18-22

A broad technical program appropriate to the region was presented at the Midwest general meeting which was held in Milwaukee, Wis., October 18–22, 1948. Thirty-four technical sessions and conferences were held in three broad fields of electrical engineering; power, industry, communication, and basic sciences. Many took advantage of the inspection trips provided to the Port Washington power plant and nearby industries which were co-ordinated with the technical program. A total of 30 important committee meetings and luncheons were held. Entertainment was provided during the evenings and a special women's program was arranged. The attendance totalled more than 1,500 members and guests, with some from as far away as California and Oregon.

OPENING GENERAL MEETING

The meeting was opened by E. W. Seeger, chairman of the Midwest general meeting committee, who introduced the Mayor of Milwaukee, Frank P. Zeidler, and AIEE President Everett S. Lee.

Mayor Zeidler gave an interesting account of Milwaukee and welcomed members and guests to the city. Speaking from an engineering background, he explained that contrary to common belief, the brewing industry was not the largest industry, but that both the heavy goods industry and the electrical industry were larger. In regard to the heavy goods industry, immigration about 100 years ago brought to Wisconsin many who were skilled in trades such as woodworking. He stated that he was particularly proud of the electrical industry, an industry capable of unlimited expansion, and that Milwaukee was not only anxious to keep the electrical industries already there, but encouraged others to come to the city.

President Lee spoke about "Our Institute" and the good friendships that he found everywhere on a recent visit to a number of the Sections and meetings.

Attention was drawn to the founding of the Allis-Chalmers Corporation from the time when Edward Allis, young New York iron molder, in 1847 set up his machine shop from which the world's largest manufacturers of heavy machinery had grown. The products of this plant, together with those of the Falk Company and other big Milwaukee companies, have helped to harness the water power of Niagara, build the Panama Canal, impound great rivers, mix concrete for the Hoover Dam, build

half of the roads in Spain. Back of all these contributions stands the electrical engineer.

President Lee also referred to three native sons of Milwaukee, General Mitchell who pioneered in advocating strong American air power, General Douglas MacArthur, and Connie Mack of baseball fame, and said "that they were great inspirational leaders who enjoyed team work, thus serving as grand examples of great lessons."

While in the State of Washington, President Lee attended the installation of the 82d Section at Richland, and on through Seattle, Portland, and Corvallis a spirit of friendliness prevailed.

He cited that the heart, head, and hand of the electrical engineer was behind all the achievements seen at many places on his trip, from the elevators and controls in the copper mines at Butte, to the air conditioning in the new hotels in Florida. When in Niagara Falls, he attended the inauguration of the 83d section. He also commented on the Washington meeting program which featured marine and electrical applications to aircraft, and recalled that back of all these is the electrical engineer.

President Lee advised that the affairs of the Institute were in good shape and that the budget for the coming year would be balanced without raising the membership dues. Membership as of October 15 had increased to 30,468, which is moving ahead. In conclusion he commented on the illness of Past-President B. D. Hull and that the many letters and gifts received brought him great pleasure and demonstrated the spirit of friendliness. He drew attention to the retirement of Doctor Vannevar Bush, who had directed great work, and his successor Doctor Karl T. Compton, both AIEE Fellows which should serve as a great inspiration for all members to carry on.

POWER SESSIONS

In the power field several important sessions were held. In two sessions on system engineering papers were presented which dealt with the planning and development of a large all-hydro system, a metropolitan electric system, and the emergency control of system loads. Others had to do with load-frequency control for interconnected systems, the designing of boiler and control equipment for fluctuating loads, and the effect of fluctuating loads on steam turbines. In another session, a series of papers presenting the a-c resistance and reactance of large cables in steel pipe, an IPCEA research committee project, constituted a valuable contribution.

Insulator contamination was the subject of five papers, two of which were from the Chicago area, and one from California. Because of the great variation in resistance which results from contamination, it did not appear likely that suitable control of the problem could be developed. Evidence was shown that dirty insulators developed one-millionth of the resistance of clean insulators. Flashover appears to develop when the leakage current reaches about 100 milliamperes. All authors favored periodic washing of insulators as the best solution of the problem at the present time. Pole fires were most likely initiated at the point of connection of the cross arm to the pole. An effective method of prevention reported was to calk around the gain with suitable compound. Burning is more likely to occur in creosoted poles than in untreated poles.

In a session on transformers, very great interest was shown in impulse testing and the subject of distribution transformers under lightning disturbances. At a subsequent meeting of the transformer committee, the methods of surge testing again was reviewed and a subcommittee was appointed to make a study of the entire problem. Several suggestions for changes and additions in the American Standards Association Standards were recommended by the committee. One of the most interesting items was the setting of the hot spot temperature rise for dry-type class *B* insulated 80 degrees centigrade transformers as 110 degrees centigrade maximum hot-spot temperature rise with a 30 degrees centigrade ambient temperature.

INDUSTRY SESSIONS

Besides two sessions on industrial control, throughout many other industry sessions the problems of control applications predominated. For example, in the mining session the evolution of Ward-Leonard control for shovels and drag lines was the subject of a paper. Great interest was shown in the symposium on speed regulating systems for paper machine drives which was very appropriate in the Wisconsin area. In the conference on material handling, control problems again were discussed in connection with electric trucks and a-c crane control.

Three sessions, ore beneficiation, open pit mining, and blooming mills, formed an appropriate theme for the Midwest and Lake Superior region. Ore beneficiation becomes increasingly more important as the supply of high-grade ores diminishes and the need to use lean ores becomes greater. The introductory talk on the subject was given by W. L. Maxson, vice-president of the Oliver Iron Mining Company, who defined ore beneficiation as the complete treatment of ores to improve their quality. Ultimately, about 15 times as much power

Milwaukee Sentinal Photo

The chief electrical engineer of the Allis-Chalmers Manufacturing Company, S. H. Mortensen (left), discusses the Midwest general meeting program with the chief electrical engineer, operations department, Southern California Edison Company, Ltd., Lloyd F. Hunt (right)

will be required as at present. Last year approximately 84 million tons of high-grade ore was shipped down from the Lake Superior region. About $2^1/_2$ times as much low-grade ore would have to be handled for the equivalent amount of pig iron. Other papers described the methods of separation employed and the power required in a large ore beneficiation plant.

The session on steel mills was timely because of the recent announcement of the new process for producing steel without rolling in a blooming mill which would save time and decrease cost. The history of the development of blooming mill drives was given in the first paper. The second paper covered the analysis of the reversing cycle and referred to the large masses of these mills. Developments of the last few years in modern motors and control permit these very large masses to be reversed more quickly. The third paper thoroughly and completely covered the applications of motors and control to the auxiliary drives of blooming mills. It indicated the trend of future development and that the auxiliary drives available will match the reversing times possible with the improved main drives. Many steel mill

Gathering at the Allis-Chalmers luncheon preceding a tour of the plant during the Midwest general meeting in Milwaukee

At one end of the AIEE board of directors' table at the Allis-Chalmers luncheon held during the Midwest general meeting are (left to right) R. T. Henry; Walther Richter, chairman, program committee; J. F. Fairman; Richard McKay; and F. O. McMillan

operators hesitate to adopt the new process previously announced, until thoroughly proved, because of the high steel quality now obtained by the blooming mill.

COMMUNICATIONS

In the field of communication the sessions on home receivers, television broadcasting, and railroad communications, proved to be of considerable interest.

The progress in coaxial telephone and television systems was reviewed in a paper by L. G. Abraham of the Bell Telephone Laboratories. He reported that certain improvements which can be made in the television terminals to give improvements in modulation products for a given signal-to-noise ratio make it seem likely that commercial television pictures eventually can be transmitted across the entire country by coaxial systems.

Recent developments in semiconductors and the transistor were described and demonstrated by Doctor J. A. Becker, Bell Telephone Laboratories. A transistor made up with a small piece of semiconductor (germanium) in size only one-fourth inch in diameter and one-half inch in length was demonstrated when used as an amplifier and as an oscillator. Power gains of a factor of 100, or of 20 decibels, readily are attained and frequencies up to 10 megacycles per second can be amplified. Output powers of 20 milliwatts or more are realized. The transistor does not have a hot cathode, hence no heatup time is required.

ENGINEERING EDUCATION

Due to the attraction and wide-spread interest in electronics in recent years on the part of students, whereas it is believed that most of them ultimately will find employment in the 60-cycle field, a series of papers was arranged to bring out the opportunities in the power field. The conference was sponsored jointly by the committee on education and the committee on Student Branches. The papers created great interest and a number of points were discussed by professors well-known in educational circles as well as students.

The first paper, presented by T. G. Le Clair of the Commonwealth Edison Company, reviewed the career breadth in the engineering field and the need for each individual to obtain the proper background. After a careful self-analysis, the individual should try and select the career for which his aptitudes, abilities, and interests best fit him.

The second paper, by A. C. Monteith, vice-president in charge of engineering, Westinghouse Electric Corporation, drew attention to the rapid expansion of industry and the power field. Within the next ten years the demand on the utility stations will have doubled. Thus a host of unsolved problems are created, such as the building of larger machines to operate at higher pressures and temperatures with attendant improvement in metals, increased power transmission voltages, improved distribution systems and the associated apparatus. Of the electrical students interviewed, by far the greater number was interested in electronics and communications, whereas the need is more like ten men interested in power to one in communications. To meet the situation, close liaison with the professors was suggested with opportunity for summer employment, provision for senior students to visit manufacturing plants, and establishment of definite training programs.

The third paper, by Frank E. Sanford, Western editor, *Electrical World*, McGraw-Hill Publishing Company, presented the career opportunities in the utility field, explained why advancement will be fast, and attributed the stability of the industry to continuous growth. In conclusion the author stated that about three-fourths of the men at management level started in the technical divisions and of the 25 largest utility systems, 12 are guided by presidents who started as engineers.

The fourth paper, by Professor E. W. Boehne of the Massachussetts Institute of Technology, advocated better methods of stimulation of teaching in the power field. He suggested that each technical committee fringing on the power field, outline the frontier problems with imagination, and prepare and publish a list of these suggestions. Such a mass presentation of lists would draw immediate attention in every institution and would assure students that the power industry did offer interesting technical frontiers.

In discussion of the subject, it was brought out that the board of directors of the Edison Electric Institute approved last June the preparation of a list of unsolved problems. The ease with which students can create in the electronic field by means of simple laboratory apparatus was cited. Another discusser pointed out that no list or stimulation was needed in the communication field. Still another point was that sufficient attention had not been given to the stimulation of training in research at the graduate level. It was reported that this idea was proposed ten years ago but that the vice-presidents of large organizations preferred to train their own men.

ALLIS-CHALMERS LUNCHEON

Tuesday noon a number of members and guests attended a luncheon in the Allis-Chalmers club house. Chairman Seeger introduced S. H. Mortensen, chief electrical Engineer, Allis-Chalmers Manufacturing Company, who in turn introduced each of the speakers. Walter Geist, president of the Allis-Chalmers Company, welcomed the guests and recalled how happy the company was to have had the AIEE group as visitors

At the speakers' table during the Allis-Chalmers luncheon, the Midwest general meeting, are (left to right) S. H. Mortensen; AIEE President Everett S. Lee; Walter Geist, president, Allis-Chalmers Manufacturing Company; E. W. Seeger, chairman, Midwest general meeting committee; W. C. Johnson, executive vice-president of the Allis-Chalmers Company; and J. Elmer Housley, AIEE past president

AIEE President E. S. Lee (left) and E. W. Seegar (center) chairman of the Midwest general meeting committee with Mayor Frank P. Zeidler of Milwaukee, Wis., during the recent AIEE Midwest general meeting in that city

during the 1937 annual summer meeting. He expressed hope that it would not be another 11 years before Milwaukee was again host to the Institute. The next speaker, W. C. Johnson, executive vice-president, pointed out that the age we are entering is not the atomic but rather the full electrical age. The electrical industry has become the link that ties all of America's industry together. As such, the the electrical industry has a serious responsibility to plan for the future. Everett S. Lee, president AIEE, spoke briefly and introduced the members of the board of directors. After the luncheon, the guests were conducted on a tour of the plant to see a variety of products in fabrication.

ENTERTAINMENT

On Tuesday evening a stag-smoker was held at the Hotel Pfister which was well attended. Members and guests enjoyed this informal occasion and a very good entertainment program.

On Wednesday evening, a banquet and dance was held in the Crystal Ballroom of the Hotel Schroeder. Music was rendered by members of the Allen-Bradley orchestra, and dancing was enjoyed. President Lee took occasion to compliment and introduce members of the Midwest general meeting committee.

On Thursday evening a "Gemuetlichkeit" (defined as having a good time the way one likes best) which was held in Lynn Hall of the Allen-Bradley Company was attended by 800 members and guests. Entertainment consisted of movies, badminton, and music and songs by the members of the Allen-Bradley orchestra, after which a buffet supper was served.

WOMENS PROGRAM

In addition to the foregoing evening events, a special women's program was arranged by Mrs. E. W. Seeger snd Mrs. E. L. McClure which consisted of teas, a tour of the Phoenix Hosiery Company, tour of the city, luncheon and style show, and a bridge luncheon. The last two events were at the Milwaukee Country Club and the Milwaukee Athletic Club, respectively.

INSPECTION TRIPS

Besides the luncheon and inspection trip to the Allis-Chalmers Manufacturing Company, many members and guests took advantage of the inspection trips arranged to the other large electrical industries in Milwaukee, the heavy goods industries, and the breweries.

"Rubber and Plastics" Papers Published in Pamphlet Form

The papers presented at the AIEE conference on electrical engineering problems in the rubber and plastics industries held in Akron, Ohio, April 20, 1948, now are available in a pamphlet covering the entire conference, including both extemporaneous and prepared discussions. This conference was the first to be sponsored by the subcommittee on rubber and plastics industries of the AIEE committee on general industry applications, a group recently formed by the main committee in keeping with its policy to increase its scope of usefulness to specialized groups not otherwise reached.

Included in the pamphlet are the following:

"Electric Power Distribution Systems for Small Rubber and Plastics Plants," H. J. Finison, B. D. Morgan, R. S. Ferguson

"Spot Conversion for Adjustable Speed Drives in Rubber and Plastics Manufacturing Plants," C. E. Robinson

"Separate Electric Equipment Rooms Versus NEMA Enclosures for Protection of Motors and Controls," F. A. Green

"Electric Braking for Rubber Mills and Calenders," B. J. Dalton

"Electric Drive Characteristics for Rubber Processing Machines," A. T. Bacheler

"The Measurement and Control of Tension and Its Relation to Motor Input," H. L. Smith

"Temperature Measurement and Control on the Electrically Heated Molding Processes for Rubber and Plastics," F. L. Spangler

"Electrical Engineering Problems in the Rubber and Plastics Industries," is $3 per copy ($1.50 to AIEE members) and may be obtained from the AIEE Order Department, 33 West 39th Street, New York, N. Y.

Future AIEE Meetings

AIEE/IRE Conference on Electronic Instrumentation in Medicine and Nucleonics
Engineering Societies Building
New York, N. Y.
November 29–December 1, 1948

AIEE Conference on Electric Welding
Engineering Society of Detroit Building
Detroit, Mich.
December 6–8, 1948

AIEE Conference on High-Frequency Measurements
Roger Smith Hotel, Washington, D. C.
January 10–12, 1949

Winter General Meeting
Pennsylvania Hotel, New York, N. Y.
January 31–February 4, 1949
(*Final date for submitting papers—closed*)

AIEE Conference on the Textile Industry
Atlanta, Ga.
Spring, 1949

AIEE Conference on Electron Tubes
March, 1949

AIEE Conference on the Rubber and Plastics Industry
Akron, Ohio
March, 1949

South West District Meeting
Baker Hotel, Dallas, Tex.
April 19–21, 1949
(*Final date for submitting papers—February 3*)

AIEE Conference on the Textile Industry
Boston, Mass.
May 4, 1949

Summer General Meeting
New Ocean House, Swampscott, Mass.
June 20–24, 1949
(*Final date for submitting papers—April 6*)

Pacific General Meeting
Fairmont Hotel, San Francisco, Calif.
August 23–26, 1949
(*Final date for submitting papers—June 9*)

Midwest General Meeting
Netherland Plaza Hotel, Cincinnati, Ohio
October 17–21, 1949
(*Final date for submitting papers—August 3*)

Winter General Meeting
New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—November 16*)

PERSONAL NOTES.......

W. H. Harrison (A'20, M'30, F'31), formerly vice-president of the American Telephone and Telegraph Company, has been elected president of the International Telephone and Telegraph Corporation, New York, N. Y. An outstanding figure in the communications field, Harrison has been identified with the telephone industry for 40 years. Born in 1892, he began working for the New York Telephone Company in 1909, followed by four years, from 1914 to 1918, as an engineer with the Western Electric Company. During that time, Harrison attended electrical engineering classes at the Pratt Institute, Brooklyn, N. Y., graduating in 1915. From 1918 to 1933, he served as an engineer with the American Telephone and Telegraph Company, and then became vice-president in charge of operations of the Bell Telephone Company of Pennsylvania. He returned to the American Telephone and Telegraph Company in 1937, as assistant vice-president, and a year later was elected vice-president. During the war years, Harrison headed the construction division of the National Defense Advisory Commission, and later was director of production in the Office of Production Management. Commissioned in the United States Army in 1942, Harrison, as a brigadier general, served as director of procurement in the Services of Supply, and later, as a major general, he took over direction of the Signal Corps Procurement and Distribution Services. Among his awards are the War Department's Distinguished Service Medal, the Most Excellent Order of the British Empire, the Cross of the French Legion of Honor, the Hoover Medal, highest engineering civilian award, and honorary degrees from the Brooklyn Polytechnic Institute, Notre Dame University, and Rensselaer Polytechnic Institute. President of AIEE in 1937–38, Harrison has been active on such AIEE committees as: meetings and papers, 1929–36; co-ordination of Institute activities, 1931–33; publication, 1931–33; award of Institute prizes, 1931–34; Alfred Noble Prize, 1932–34; communications, 1935–36; Lamme Medal, 1935–38; executive, 1936–40; Institute policy, 1938–40. He is also a member of Tau Beta Pi and Eta Kappa Nu.

A. H. Taylor (A'19, F'46), chief consultant for electronics, United States Naval Research Laboratory, Washington, D. C., has retired after 31 years of service to the Navy. Born in Chicago, Ill., in 1879, Doctor Taylor began his research while still an electrical engineering student at Northwestern University. After graduation he taught physics at both Michigan State College of Agriculture and Applied Science, East Lansing, and the University of Wisconsin, Madison. In 1909, Taylor received his doctorate and became head of the physics department at the University of North Dakota, continuing research in experimental radio. During World War I, he served with the United States Navy, and organized the original low-frequency transatlantic communication net. Later he served as director of the Naval Aircraft Radio Laboratory. As a civilian in 1923, Doctor Taylor became superintendent of the radio division of the newly organized Naval Research Laboratory in Washington, D. C. In this position, he was a leader in the application of higher radio frequencies to communications, radar, and electronics systems. Among Doctor Taylor's awards are the Presidential Medal for Merit, the Morris Liebman Memorial Prize of the Institute of Radio Engineers, the IRE Medal of Honor, and the John Scott Medal of the Franklin Institute. He also served on the AIEE communications committee from 1936 to 1942.

J. W. Asmann (A'32), assistant superintendent of the electric operating department, Cincinnati (Ohio) Gas and Electric Company, has been made assistant manager. He has been with the company since 1927, beginning in substation maintenance and working up through the positions of test engineer and operating engineer. Other changes within the same company include: **W. R. Weise** (M'46) has been appointed superintendent of planning and engineering. He was formerly assistant superintendent of electric distribution. **C. L. Trout** (A'36), former superintendent of overhead transmission and trouble, is now superintendent of operation and construction, consolidating all construction and operating work under his jurisdiction. Two other men elevated to superintendent were: **F. E. Pinckard** (A'23), methods and procedures; **E. F. Nuezel** (A'27, M'39), underground engineering. **S. M. Hamill** (A'28, M'36) was named manager of the electric operating department for the company.

Harold Goldberg (A'35, M'44), formerly principal research engineer, research department, radio division, Bendix Aviation Corporation, Baltimore, Md., recently was appointed chief of the ordnance research section of the National Bureau of Standards, Washington, D.C. He is well-known for his work in connection with microwave research and communications systems including television. A native of Milwaukee, Wis., Doctor Goldberg holds four degrees, including doctorates in electrical engineering and physiology, from the University of Wisconsin. He is a senior member of the Institute of Radio Engineers, and also holds membership in the American Physical Society, the American Association for the Advancement of Science, and Sigma Xi and Tau Beta Pi fraternities. He holds four patents granted in the field of electronics and has some 50 others pending. Among his more important designs and developments were the *SCR-588* radar receiver, the *S-C* Mark *II* air-borne vest pocket modulator, and the *SCR-66T5-2* radar set.

C. I. MacGuffie (A'27, M'43) and **R. C. Freeman** (M'44) have been appointed manager of sales and manager of engineering, respectively, of the General Electric Company's welding divisions, Schenectady, N. Y. MacGuffie was formerly manager of sales, welding equipment division, and has been with the company since graduating from Pennsylvania State College in 1925. He is a director of the American Welding Society. Freeman has been with the company since graduating from the University of Minnesota in 1929. He is a member of the American Welding Society, the National Committee on Electric Welding, and is chairman of the subcommittee on electric arc welding of the American Standards Association.

F. J. Scudder (M'25) has retired as director of switching development, Bell Telephone Laboratories, Inc., New York, N. Y., after 30 years with the Bell company. He was responsible for the development of the first common control dial system, which resulted in the No. 1 crossbar system being made standard for large city dial offices. **A. J. Busch** (A'24, M'30), formerly assistant director of switching development for the Bell Laboratories will succeed Scudder as director of that department. Busch, a graduate of the Polytechnic Institute of Brooklyn, has been with the Bell company since the early 1920's. He was in charge of the development of common control systems including the latest switching system known as the No. 5 crossbar system.

A. H. Brolly (A'27), television engineer formerly with television station *WBKB*, Chicago, Ill., is now chief engineer of Television Associates, Inc., of Chicago, an engineering and manufacturing company. An

W. H. Harrison

A. H. Taylor

H. Goldberg

electrical engineering graduate of the University of California in 1926, Brolly took his graduate work in industrial management at Harvard University. His technical career includes six years as chief engineer in charge of development for Farnsworth Television, Inc., and three years as project engineer in the television laboratory of the Philco Corporation. He joined station *WBKB* in 1940 as chief engineer. Holder of many patents in electronics, Brolly was also author of a wartime mathematics text for the United States Navy. He is a senior member of the Institute of Radio Engineers and a member of Eta Kappa Nu fraternity.

W. F. Kean (A '42), head of the broadcast consulting division of the Andrew Corporation, Chicago, Ill., since its formation in 1944, has been appointed as that company's general sales manager. A graduate of the University of Wisconsin, Kean is well-known as a radio engineer and an authority on broadcast installations. In his new capacity, he will be responsible for all sales contracts and policies of the Andrew Corporation. That company also announces the promotion of **J. S. Brown** (A '40) from assistant chief engineer to chief engineer. Brown has been with the firm since 1943 and has been active in the development and manufacturing design work on transmission lines and antenna equipment. A senior member of the Institute of Radio Engineers, he has authored a series of articles on antenna and coaxial transmission line installation problems for both frequency modulation and television.

J. F. Fairman (A '20, F '35), vice-president of the Consolidated Edison Company of New York, Inc., New York, N. Y., has been elected vice-president of the United Engineering Trustees, Inc., a corporation set up jointly by the four national engineering Founder Societies. The corporation promotes the advancement of the engineering arts and sciences in all their branches through two departments, the Engineering Foundation and the Engineering Societies Library. Fairman, a director of AIEE (1946–50), has served on the following AIEE committees: safety codes, 1931–34; general power applications, 1934–36; electric machinery, 1936–37; technical program, 1941–42, 1945–47; board of examiners, 1941–44; executive, 1944–47; Institute publicity, 1946–47; Edison Medal, 1947–49; planning and coordination, 1945–48 (chairman, 1945–47).

J. A. Hutcheson (M '44), director of the Westinghouse Research Laboratories, East Pittsburgh, Pa., has received the Westinghouse Order of Merit for his engineering achievements and his able direction of research activities. The award, highest conferred by the Westinghouse Corporation to an employee, was voted to Doctor Hutcheson by the board of directors. A graduate of the University of North Dakota in 1926, Hutcheson has been with Westinghouse since that year. He became assistant director of the research laboratories in 1943 and was appointed director early in 1948. He has been on the AIEE research committee since 1945, and served on both the nucleonics and joint subcommittee on electronic instruments for the year 1947–48.

Vannevar Bush (A '15, F '24), retiring president of the Research and Development Board of the national military establishment, has been chosen to receive the 1949 Industrial Research Institute Medal for outstanding contribution to the field of industrial research. The medal will be presented February 3, 1949, during the Institute's winter meeting. Doctor Bush resigned his post with the Research Board to devote more time to the presidency of the Carnegie Institution of Washington. Very active in AIEE activities prior to World War II, Bush has served on the following AIEE committees: electrophysics, 1924–33; power transmission and distribution, 1925–29; research, 1924–30; education, 1928–29; meetings and papers, 1929–33, 1939–41; Edison Medal, 1933–38; Lamme Medal, 1936–39; coordination of Institute activities, 1937–38; board of directors, 1937–41.

W. E. Mitchell (A '06, F '22), former president of the Georgia Power Company, Atlanta, has been appointed chief of the industrial mission to France of the Economic Cooperation Administration. He will screen French requests for industrial equipment and make recommendations for allocations of American aid. He had been with the Georgia utility since 1927, after 15 years with the Alabama Power Company. Elected president in 1945, after holding various executive positions, he retired in 1947. Mitchell served on the AIEE transmission and distribution committee from 1914 to 1917 and on both the power transmission and distribution committee and the power generation committees from 1924 to 1929. From 1931 to 1935, he served on the AIEE committee on codes of principles of professional conduct.

F. E. Hudson (A '26, M '32), formerly electrical engineer and rate specialist with the Bangor (Maine) Hydro-Electric Company, is now with the consulting engineering firm of Day and Zimmerman, Inc., Philadelphia, Pa., as assistant to the vice-president. He will conduct investigations and make reports involving electrical engineering problems for utility and industrial companies. Previous to his affiliation with the Maine utility, Hudson was with public utility companies in eastern United States and Canada as an electrical engineer. During World War II, he served as an officer in the United States Navy.

H. M. Pope (A '20, M '30), general commercial problems engineer since 1933 for the American Telephone and Telegraph Company, New York, N. Y., has announced his retirement. A native of England, Pope joined the Bell System upon coming to the United States in 1909. During World War I, he served with the Signal Corps, and in 1921, became an engineer for the New York Telephone Company. He transferred to American Telephone and Telegraph Company in 1923.

L. W. Goostree, Jr., (A '42), former district representative in Dallas, Tex., for the electronics department of the General Electric Company, has been appointed sales manager in charge of marine electronic equipment with headquarters at Electronics Park, Syracuse, N. Y. A graduate of Southern Methodist University, with a bachelor of science degree in electrical engineering, Goostree has been with the company since 1941, except for eight months at the Massachusetts Institute of Technology's Radiation Laboratories, working on government projects. He is a member of Sigma Tau fraternity.

J. N. Banky (A '44), electrical engineer with the Allis-Chalmers Company, Milwaukee, Wis., has been named a sales representative in the company's Chicago, Ill., district office. He has been with the Allis-Chalmers Company since 1943. Banky received his master of science degree in electrical engineering from the Illinois Institute of Technology in 1947 by virtue of a graduate fellowship in power systems engineering received from the Allis-Chalmers Company.

V. L. Cox (A '28, M '44), formerly assistant manager of engineering, switchgear divisions, General Electric Company, Schenectady, N. Y., has been named manager of that division. Prior to joining the switchgear divisions last November, Cox was assistant engineer at the company's Philadelphia, Pa., works where he had worked since 1928. He has been with the General Electric Company since his graduation from the University of North Dakota in 1926.

G. M. Bell (A '32), former sales engineer in the Montreal, Quebec, Canada, office of the Canadian Westinghouse Company Limited, has been appointed sales manager of the Montreal office of the Commonwealth Electric Corporation. Bell received his bachelor of science degree in electrical engineering from the University of Manitoba in 1931, and since then has been employed in both engineering and sales capacities with leading Canadian electrical companies.

J. H. Vivian (A '34, M '40), electrical and mechanical engineer for the Southern California Edison Company, Ltd., Los Angeles, has been promoted to chief engineer of that company's division of apparatus and protection. Vivian has served on several AIEE committees including: protective devices, 1945–48, 1940–42; automatic stations, 1944–48; substations, 1944–48; switchgear, 1947–49; relays, 1947–48.

L. J. Dylewski (A '36), underground supervisor at Miami for the Florida Power and Light Company, has been appointed sales engineer for the G & W Electric Specialty Company. During World War II, Dylewski served as a captain with the United States Army Signal Corps.

J. H. Belknap (A '23, M '34), national president of Sigma Tau fraternity and chairman of the engineering division of the University of Rochester, N. Y., has been appointed dean of the graduate division of the United States Airforce Institute of Technology, Wright-Patterson Air Base, Dayton, Ohio. He will be in charge of graduate training of

Air Force officers and enlisted men in training procedures associated with the nation's industrial mobilization plan. Doctor Belknap was on the AIEE education committee from 1939 to 1942.

C. S. Cole (A '30, M '35), superintendent of electrical and mechanical maintenance for the Niagara Falls (N. Y.) Power Company, has been promoted to assistant general superintendent of that company.

L. L. Weldy (A '42), formerly sales engineer for the Weston Electrical Instrument Corporation and the I-T-E Circuit Breaker Company, has been appointed representative of the Electric Power Equipment Corporation to cover the territory of northern Illinois, Iowa, eastern Wisconsin, and northwestern Indiana.

V. E. Dodson (A '43), formerly with the engineering division in the San Francisco, Calif., office of the General Electric Company, has been appointed Pacific district manager of that company's apparatus department in that city.

H. R. Wakeman (M '45), superintendent of distribution for the Portland, Oreg., office of the General Electric Company has announced his retirement effective August 31, 1948, after 41 years of service.

James Boyd (M '40), former eastern district manager, Westinghouse Electric Corporation, has been appointed general sales manager of the Hamilton, Ohio, division of the Lima-Hamilton Corporation.

W. P. Lewis (A '31, M '42) has been appointed district electrical sales engineer for the American Steel and Wire Company, Pittsburgh, Pa. He will be in charge of a new and separate sales division created to handle that company's products which will have four regional offices.

G. W. Lawrence (A '19), president and general manager of the Sangamo Company Ltd., Leaside, Ontario, Canada, was elected president of the Canadian Electrical Manufacturers Association at their recent annual meeting.

M. A. Lipton (M '46) has been awarded a citation by the United States Army Signal Corps for outstanding performance as electrical engineer in charge of the installation and testing of wire communication apparatus at the Bikini Atom Bomb tests.

H. A. Leedy (M '46) has been named director of the Armour Research Foundation of the Illinois Institute of Technology, Chicago. Doctor Leedy has been acting director of the foundation since last March and previously had served, since 1944, as chairman of physics research.

J. M. Dollenmaier (A '40), former assistant vice-president of Line Material Company, Milwaukee, Wis., has been appointed sales manager of the Kuhlman Electric Company, Bay City, Mich. A graduate of the Armour Institute of Technology, Dollenmaier received his early training as a student engineer with the Public Service Company of Northern Illinois, and as assistant engineer on the Illinois Commerce Commission.

Ward Harrison (F '36), who recently resigned as director of engineering at the General Electric Company's Nela Park division, has joined the staff of Curtis Lighting, Inc., of Chicago, Ill., as engineering consultant.

C. T. Mess (A '27, M '29) has been appointed assistant director of public utilities for the California Public Utilities Commission. Mess was formerly chief valuation engineer for the California Railroad Commission.

H. V. Barr (A '44) has been appointed superintendent of the Tidd generating plant of the Ohio Power Company at Brilliant. Barr was formerly at the company's Philo plant, serving in various engineering positions until promotion and transfer as assistant superintendent at the Tidd plant in 1947.

K. T. Compton (F '31), president of the Massachusetts Institute of Technology, Cambridge, has resigned his post after 18 years of service. He will become chairman of the Research and Development Board of the National Military Establishment, Washington, D. C.

C. H. Black (A '41, M '45), former manager of engineering for the switchgear divisions of the General Electric Company, Schenectady, N. Y., has been appointed manager of the company's construction materials divisions.

L. M. Goldsmith (M '26), chief engineer, Atlantic Refining Company, Philadelphia, Pa., has been awarded the President's Certificate of Merit in recognition of outstanding services as a member of the transportation division, national defense research committee, Office of Scientific Research and Development, during World War II.

F. R. Lack (M '37), a member of the board of directors of the Westrex Corporation, New York, N. Y., has been elected president of that company, a subsidiary of the Western Electric Company. The company, a distributor of theater, studio, and associated equipment, provides complete equipment service to the motion picture industry in the territories it serves.

OBITUARY • • • • • •

Lee F. Adams (A '09, M '26, F '42), General Electric Company standards consultant, died October 14, 1948. He was born November 26, 1885 in Milesburg, Pa. and was an electrical engineering graduate of Pennsylvania State College. While in college, he worked in the testing department of the General Electric Company, and later as instructor in electrical engineering until 1909. From 1909 to 1912, Adams was a designer in the induction motor department at the Schenectady plant of the General Electric Company. From 1912 to 1929, he was application engineer in that company's industrial department. He switched to the commercial department as a commercial engineer in that latter year and remained in that position until 1938, when he was named assistant to the vice-president and manager of the newly formed standard department in charge of co-ordinating the development and application of standards through the GE organization. Active in AIEE activities, Adams served on the following committees: electric machinery, 1929–31; safety, 1936–48; domestic and commercial applications, 1940–46; technical program, 1945–47. He also was representative to the Apparatus Makers and Users Committee of National Research, and a member of the United States Committee of the International Electrotechnical commission from 1929–32. Adams also served as chairman of the standards council of the American Standards Association. He is the author of a number of papers on application engineering, standards, and codes. His society affiliations include membership in the American Society of Testing Materials, Society of Automotive engineers, and the National Safety Council.

Bernard Price (A '10), resident director, Victoria Falls and Transvaal Power Company, Ltd., Johannesburg, South Africa, died July 9, 1948. He was born July 1, 1877, and was educated at St. Dunstans' College, Catford, London, England, and the Central Technical College, London, England, graduating in 1896. His first position was in the shipbuilding industry, but in 1898, he began working for the testing department of a leading London dynamo works. In 1901, Price joined the consulting engineering firm of Merz and McLellan, London, as a junior assistant. He was elevated to the position of chief engineer of the electrical department of that firm in 1903. In 1909, Price was appointed chief engineer of the Victoria Falls & Transvaal Power Company, and managing director of its subsidiary, the Rand Power Company. During 1928, Doctor Price became general manager of the Victoria Company, but relinquished the title upon becoming resident director in 1936, the position he held until his death. Very active in scientific fields in South Africa, Price had been president of both the South African Institute of Electrical Engineers and the South African Institution of Engineers, and of the Associated Scientific and Technical Societies of South Africa. He also established the Bernard Price Institute of Geophysical Research and the Bernard Price Foundation for Palaeontological Research. In his will, he left over £150,000 to scientific and social charities.

E. Rowland Hill (A '99, M '05, F '12), chief engineer of the Westinghouse-International Corporation, died August 25, 1948. Born in Pompton, N. J., on January 29, 1872, he took mechanical and electrical engineering degrees from Cornell University in 1893. Hill began his general shop training with the Westinghouse Electrical and Manu-

facturing Company (now the Westinghouse Electric Corporation) in Pittsburgh, Pa., and in 1895 became a special engineer for that firm. Working with George Westinghouse, he helped develop electropneumatic multiple unit control systems and other electric equipment until 1901, at which time he was sent to the London, England, office of the Westinghouse company. He was placed in charge of all electrical, steam, mechanical, and general engineering, including the design and construction of railway stations throughout Great Britain. Returning to the United States in 1906, Hill worked until 1912 as engineer of electrical traction for the Pennsylvania railroad. During that time, he was instrumental in the electrification of both the Pennsylvania and Long Island railroad tunnels. From 1912 to 1924, Hill was a partner in the consulting engineering firm of Gibbs and Hill, and in 1925, he became president of that firm. During recent years, he designed numerous industrial power plants and electrical facilities, and during World War II, designed power installations for the Armed Forces. An active member in both professional and philanthropic circles, he was president of the American Institute of Consulting Engineers for 25 years. He was entered as an AIEE life member in 1936.

Cecil E. Haller (A '43), development engineer, tube department, RCA Victor division, Radio Corporation of America, Lancaster, Pa., died July 6, 1948. Born in Houston, Ohio, on January 15, 1908, Haller was a graduate of Ohio Wesleyan University in 1930. He received the degree of master of science in applied mathematics from the University of Pittsburgh in 1932. From 1930 to 1934, Haller was employed in the research department of the Westinghouse Corporation as a developer of vacuum tubes. He followed this with two years as tube engineer for the Kenrad Corporation of Owensboro, Ky., and in 1936, joined RCA at its Harrison, N. J., plant where he was assigned to work on the development of transmitting tubes. At the war's outbreak, he was transferred in the same capacity to the RCA Lancaster, Pa., plant. In 1947, Haller was named manager of the development shop there, and directed its activities until his death. He was the author of several technical papers and held several patents in the tube development field. Haller also was an instructor in radio fundamentals at Rutgers University, New Brunswick, N. J. He was a senior member of the Institute of Radio Engineers and a member of the American Physical Society. Haller also was affiliated with the Pi Mu Epsilon and Sigma Pi Sigma fraternities.

Samuel W. Rushmore (A '00), inventor and automotive engineer, died August 16, 1948. He was born April 2, 1871, in Philadelphia, Pa., and received his technical training from the Pratt Institute. At the age of 16, Rushmore entered the electrical field as an apprentice for the Excelsior Electric Company of Brooklyn, N. Y. From 1891 to 1893, he was employed as an expert in charge of manufacturing, testing, and installing of electric apparatus by the Sprague Electric Railway and Motor Company and other concerns, including the Edison Phonograph Works in New Jersey. He began the Rushmore Dynamo Works in 1893 and produced searchlights of his own invention. This light, a horizontal carbon type, was proved very successful and was used extensively on many naval vessels. In 1903, Rushmore moved to larger plant facilities in New Jersey and continued work on several inventions including automotive light devices, an automobile self-starter, a steam-cooled automotive system, and a noncrater producing explosive shell for the United States Army. In 1914, Rushmore sold his firm to a German company, and retired at the age of 43. His continued research in his private laboratory caused him to take out over 100 patents in the years that followed. He was a life member of the AIEE since his enrollment in 1938.

William Roth Work (A '08, F '40), assistant director of the Carnegie Institute of Technology's college of engineering and science, Pittsburgh, Pa., died October 3, 1948. He was born in Steelton, Pa., on May 4, 1881, and received degrees from both Wittenberg Academy, Springfield, Ohio, and Ohio State University, in 1902 and 1905 respectively. He became a part-time instructor at the Carnegie institute while working for the Westinghouse Electric Corporation during 1905–06. In 1906, Doctor Work was appointed as an instructor in electrical engineering on the Carnegie faculty, and three years later became an assistant professor. After five years as an associate professor, Work became a full professor and head of the department of electrical engineering in 1920. In 1942, he was appointed assistant director of the engineering college. Doctor Work was a Fellow of the American Institute for the Advancement of Science, and a member of both the American Society for Engineering Education, and the American Association of University Professors. As a member of AIEE, Doctor Work served on the education committee from 1919 to 1931, as chairman in 1930–31, and on the meetings and papers committee in 1930–31.

Wilber C. Snow (A '20, M '26), assistant superintendent, Department of Lighting, Seattle, Wash., died May 20, 1948. He was born in Aurora, Ill., on November 8, 1886, and received most of his technical training at the University of Illinois. Almost all his engineering work had been on the Pacific coast. In 1909, Snow began electrical construction work with the Seattle-Tacoma (Wash.) Power Company, and became assistant superintendent in 1911. In 1912, he began electrical distribution work for the Puget Sound Traction Light and Power Company, Seattle division. Snow joined the Seattle Department of Lighting as a power salesman at the end of 1912, and was with that department until assuming duties as supervisory electrical engineer with the construction division of the United States Army in 1917. He returned to the Seattle lighting department in 1919, and spent the next two years as assistant to the resident engineer, finally returning to the commercial division as power salesman, and later, as consultant with customers on electrical and mechanical engineering problems. In recent years, as assistant power and light superintendent, he had done considerable experimental work on applications of electric energy for use in home heating and appliances, and the use of electricity as a substitute for coal and oil in homes and industries.

Charles E. Bonine (A '03, M '45), consulting engineer in Philadelphia, Pa., and former associate director of the Franklin Institute, died October 25, 1948. He was born in Emporium, Pa., on July 1, 1874, and graduated from the electrical engineering course of the Drexel Institute in 1896. He worked successively as draftsman, chief draftsman, assistant superintendent, and chief engineer of the Electro-Dynamic Company of Philadelphia from 1896 to 1906, and then left to become president and general manager of the Rossmassler-Bonine Electric Company, a motor manufacturing and design firm. In 1910, Bonine began as a consulting engineer in the Philadelphia area, and in 1930, he became associate director of the Franklin Institute Museum. Among his inventions were developments of the automobile automatic starter, electric and mechanical equipment for the Holland-type submarine, and various processes in use in the textile, chemical, and metal industries. He was a member of both The American Society of Mechanical Engineers and the American Electro-Chemical Society, and a Fellow of the American Association for the Advancement of Science.

Earl L. McClure (A '37, M '41), electrical engineer for the Wisconsin Electric Power Company, Milwaukee, died September 2, 1948. He was born in Van Wert, Ohio, on August 17, 1899, and took his electrical engineering degree at the University of Illinois in 1921. McClure began working for the Milwaukee Electric Railway and Light Company (now the Wisconsin Electric Power Company) in 1921 as a junior engineer and was with the company until his death. From 1922 until 1924, he was employed as a voltage regulator, and followed that with two years as starting and load engineer in charge of checking new equipment and the installation of line additions based on load growth. McClure became system operator in 1926 and was responsible for supervision of load dispatching and emergency measures. In 1928, he was appointed assistant system engineer for the company. In this capacity, he was in charge of system development, special investigations, and supervision of relay engineering, as well as development of electric devices for electric power use. He was the author of several articles in technical journals covering phases of his work and held patents on devices he developed. An active member of AIEE, he was also a member of Eta Kappa Nu and Sigma Tau.

Arthur M. Unger (A '40), development engineer of the Pullman Standard Car Manufacturing Company, Chicago, Ill., died during September 1948. Born in Telluride, Colo., on November 5, 1907, he received the degree of electrical engineer from the University of Colorado in 1929. A graduate of the Westinghouse student course

he was employed in that company's supply engineering department from 1930 to 1931, and in the motor engineering department until 1934. From 1935 until recent years, Unger was chief welding engineer for the Pullman Company, in charge of all welding development and procedure. Since his joining the Pullman engineering department, all standard cars have been changed from riveted style to completely welded bodies. For the past few years, Unger had been development engineer for the company. He was a member of both the American Welding Society, and the American Society for Metals, and an author of many welding articles.

Archer K. Jones (A '16), retired administrative assistant in the executive department of the Florida Power and Light Company, Miami, died September 6, 1948. Born in Orleans, Nebr., on February 7, 1883, Jones received his early electrical training with the Western Electric Company in 1902, and from 1902 until 1907, with the United States Navy as a chief electrician. For many years following, Jones was employed by the Compania de Luz y Fuerza Electrica of Costa Rica as an electrical engineer. He also held several engineering and executive positions in electrical utility industries in Cuba and Chile. At one time he was president and general manager of the Cuban Electric Company of Havana, and later was president and general manager of the Chilean Electric Company. He had been with the Florida Power and Light Company since 1938.

Francis W. Mahoney (A '09, M '22), a partner in Mahoney and Webb, consulting engineers of Boston, Mass., died August 21, 1948. A native of Boston, Mass., he was born July 8, 1883, and attended Massachusetts State College. From 1906 to 1908, Mahoney was employed as an electrical draftsman by Densmore and LeClear, Engineers, of Boston. From 1908 to 1909, he was electrical engineer in charge of switchboard design for the Taunton and New Bedford Copper Company, Taunton, Mass., but in that latter year, returned to Densmore and LeClear as electrical engineer in charge of the electrical department. After a number of years in that capacity, Mahoney opened his own office as a consulting engineer.

John Oliver Carr (A '22), vice-president of the Teletype Corporation, Chicago, Ill., died August 24, 1948. He was born in Bangor, Maine, on December 23, 1899. After two years in college, studying chemical engineering, Carr went to work for both the General Electric Company and the Western Telegraph Company as an electrical technician. His service with the Teletype Company began 35 years ago, prior to that company's affiliation with the American Telephone and Telegraph Company in 1930. In the past, he had been development engineer, general manager, treasurer, and vice-president of the firm.

R. E. G. Horley (A '21), works manager and chief engineer at the Eastleigh factory of Pirelli-General Cable Works, Ltd., Southampton, England, died recently. He was born in London, England, January 27, 1892, and received his technical training at the Battersea Polytechnic School, finishing in 1912. From 1912 to 1915, Horley was a junior member of the testing staff of the British Insulated and Helsby Cable Company. In 1915, he joined the Pirelli-General Cable Works as chief assistant of electrical testing, and after two years was made chief electrician. He subsequently was promoted to chief engineer and manager of the Eastleigh works, the position he held at his death.

Arthur J. Gowan (A '23) of the United States Engineer Office, Rock Island, Ill., died August 17, 1948. He was born in Waterville, Maine, on February 25, 1887, and was a graduate in electrical engineering from Stanford University in 1909. Gowan was with the General Electric Company from 1909 to 1911, and then became a General Electric engineer assigned to various parts of the United States until 1920. From that date, and for several succeeding years, Gowan was the General Electric engineer at that company's Lynn, Mass., works. In recent years, he had been with the government engineering service in the Midwest.

Charles F. Bancroft (A '95, F '12), retired engineer and AIEE life member, died October 25, 1948. Born in Mansonville, Quebec, Canada, December 17, 1874, he received his education from the Lincoln College, Sorel, Canada, and the Edison General Electric Company's student course. After graduation, he went into electrical railway work in New England, and rose to become chief engineer of the Massachusetts Street Railway System. He held several patents on street lighting arresters which he designed, and was noted for being one of the first engineers to build a steam-turbine electric power plant.

D. C. Durland (A '08), chairman of the board of the Canadian General Electric Company, Ltd., died October 19, 1948. Born in New York City on September 7, 1872, Durland was graduated from Princeton University in 1894 as an electrical engineer. He joined General Electric in the fall of that year and was with that company and its affiliates for the next 54 years. He became a director of the Canadian company in 1924, and was named president of the board in 1941. In this latter year, he also was named president, an office he held until 1946.

Benjamin Davis (A '39), associate electrical engineer, Industrial Laboratory, United States Navy Yard, Mare Island, Calif., died October 8, 1948. He was born August 8, 1914 in Oakland, Calif. He was a graduate of the University of California in 1938, and had been employed in an engineering capacity at the Navy Yard since the fall of that year. Davis was a member of the Institute of Radio Engineers, and of Tau Beta Pi and Eta Kappa Nu fraternities.

William K. Archbold (A '94, M '13), retired engineer, died October 27, 1948. Born in 1866 in Ohio, Archbold received his technical training at Cornell University, graduating in 1889. He began working for the Westinghouse Company in that year, doing both engineering and construction work for them until 1900. He then formed the Archbold-Brady Company, makers of structural steel fabricators for electrical transmission structures, in Syracuse, New York. He served as both president and engineer in charge of electrical transmissions and allied work. One of his major accomplishments was the direction of design, fabrication, and erection of the first steel towers used to transmit electricity generated at Niagara Falls to the cities of Buffalo, Rochester, and Syracuse.

MEMBERSHIP • • • •

Recommended for Transfer

The board of examiners at its meeting of October 21, 1948, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Fritz, L. J., plant div. engr., The Ohio Bell Tel. Co. Dayton, Ohio.

1 to grade of Fellow

To Grade of Member

Binkley, E. R., elec. designer, United Engineers & Constructors, Inc., Phila., Pa.
Camerlengo, J. M., staff asst., power trans. test, General Elec. Co., Pittsfield, Mass.
Carson, D. B., application engr., General Elec. Co., Los Angeles, Calif.
Carter, J. C. G., design engr., Lansdowne Plant, Westinghouse Elec. Corp., Baltimore, Md.
Colteryahn, H. C., distribution service engr., Union Elec. Co. of Missouri, St. Louis, Mo.
Crumb, A., elec. engr., Bonneville Pr. Admstr., Pittsburgh, Pa.
Ecker, H. W., design engr., Minnesota Mining & Mfg. Co., St. Paul, Minn.
Ford, L. C., application & service engr., General Elec. Co., Pasco, Wash.
Gaffney, D. A., supt. elec. trans. & distr., Central New York Power Corp., Utica, N. Y.
Goodrich, R. D., Jr., elec. engr., Bureau of Reclamation, U. S. Govt., Denver, Colo.
Hansford, E. M., elec. engr., works engr. dept., Electro Metallurgical Co., Alloy, W. Va.
Harris, L. J., staff elec. engr., Aluminum Co. of America, Alcoa, Tenn.
Harter, E. F., elec. engr., Kimble Elec. Div., Miehle Printing Press & Mfgr. Co., Burlington, Iowa
Hicks, I. C., machy. electrification mgr., S. W. district, Westinghouse Elec. Corp., St. Louis, Mo.
Hoisington, D. B., asst. prof., elec. engg., U. S. Naval School, Monterey, Calif.
Jimenez-Michelena, L. G., pres. & acting chief engr., Intelec, S. A., Caracas, Venezuela.
Klippel, O. H., elec. designer, Fluor Corp. Ltd., Pasadena, Tex.
Mooney, R. L., sales engr., Square D Co., Canada, Ltd., Montreal, Quebec, Canada
Rich, C. S., editor *ELECTRICAL ENGINEERING*, New York, N. Y.
Sander, V. A., asst. elec. engr., W. N. Matthews Corp., St. Louis, Mo.
Schaefer, F. J., elec. supt., Stone & Webster Engg. Corp., Schenectady, N. Y.
Sparrow, K. M., elec. engr., Continental Elec. Co., Inc., Rockford, Ill.
Swanson, L. W., senior elec. engr., C. F. Braun & Co., Alhambra, Calif.
Wagner, R., Jr., senior engr., New York Tel. Co., Brooklyn, N. Y.
Wills, E. E., asst. mgr., Wm. Wurdack Elec. Mfg. Co., St. Louis, Mo.
Wood, J. P., elec. engr., National Aniline Div., Allied Chemical & Dye Corp., Buffalo, N. Y.
Woodbury, H. L., assoc. elec. engr., public service dept., City of Glendale, Glendale, Calif.

27 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before December 21, 1948, or February 21, 1949, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Fellow

Sadiq, S. A., Pakistan Public Works Dept., Karachis Pakistan

1 to grade of Fellow

To Grade of Member

Anderson, R. L., Jack & Heintz Precision Industries, Inc., Bedford, Ohio
Bauler, J. W., Federal Tel. & Radio Corp., Clifton, N.J.
Blakeman, S. P., Haughton Elevator Co., Philadelphia, Pa.
Burke, C. E., General Elec. Co., Pittsfield, Mass.
Caddock, R., Western Elec. Co., Kearny, N. J.
Calhoun, O. L., Crossett Paper Mills, Crossett, Ark.
Caywood, M. G., J. M. Huber Corp., Borger, Tex.
Clarke, S. H., Bepco Canada Limited, Montreal, Quebec, Canada
Cobb, F. C., Public Service Elec. & Gas Co., Newark, N. J.
Connolly, E. F., Hydro-Elec. Power Comm. of Ontario, Toronto, Ont., Canada
Crockett, C. C., La. Power & Light Co., New Orleans, La.
Derry, J. A., Atomic Energy Comm., Washington, D. C.
Elmore, F. B., Southwestern Public Service Co., Borger, Tex.
Falconer, R. D., Amalgamated Elec. Corp., Toronto, Ontario, Canada
Faust, D. G., Walter Kidde & Co., Inc., Corp., Belleville, N. J.
Ginsberg, D., Dept. of the Army, Ft. Belvoir, Va.
Goodman, L. N., 409 Audubon Bldg., New Orleans, La.
Haas, P. G., Boston & Maine R. R. Co., Boston, Mass.
Harman, M. C., S. & C. Elec. Co., Chicago, Ill.
Harsin, J. C., Madison Light & Power Co., Madison, Ind.
Hayden, G. W., Pacific Gas & Elec. Co., Fresno, Calif.
Hegler, R., Univ. of Michigan, Ann Arbor, Mich.
Hewett, R. S., Brown Instrument Co., Philadelphia, Pa.
Howe, W. M. (re-election), General Elec. Co., West Lynn, Mass.
Johnson, A. G., Omaha Public Power Dist., Omaha, Nebr.
Kartluke, P., General Elec. Co., New York, N. Y.
Keene, J. V., Electricity Dept. Kuala Lumpur, Malaya.
Lee, R. E., Gulf States Utilities Co., Beaumont, Tex.
Legg, L. E., Chicago & Northwestern Railway, Chicago, Ill.
Lennie, G., McCarthy & Robinson, Ltd., Toronto, Ontario, Canada
Ludwig, A., Western Elec. Co., Kearny, N. J.
Marco, G. P., Clark Equipment Co., Battle Creek, Mich.
McDonald, D., Aeronautical Research Center, Willow Run Airport, Ypsilanti, Mich.
Milch, M., 1511 Park Road N. W., Washington, D. C.
Montague, J. R., The Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Redshaw, E. M., Australian General Elec. Pty. Ltd., Auburn, N. S. W., Australia
Richmond, H. R., Jr., Bonneville Power Admin., Walla Walla, Wash.
Riggle, G. C., David Taylor Model Basin, Washington, D. C.
Saari, L. V., Wisconsin Tel. Co., Milwaukee, Wis.
Schneider, W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Storer, B. W., Commonwealth Edison Co., Chicago, Ill.
Vitucci, A. S., Western Union Tele. Co., New York, N. Y.
Walker, W. R., General Elec. Co., New York, N. Y.
Ward, J. F., Light Div., City of Tacoma, Wash.
Welch, R. C., General Elec. Co., Fort Wayne, Ind.
Wilbur, G. B., General Elec. Co., Philadelphia, Pa.
Wisbon, C. B., Toledo Edison Co., Toledo, Ohio

47 to grade of Member

To Grade of Associate

United States, Canada, and Mexico

1. North Eastern

Anderson, J. G., General Elec. Co., Pittsfield, Mass.
Corson, C. A., Ingersoll-Rand Co., Painted Post, N. Y.
Courtin, J. J., Westinghouse Elec. Corp., Buffalo, N. Y.
Freeman, J. J., United Illuminating Co., New Haven, Conn.
Grabert, B. M., U. S. Rubber Co., Bristol, R. I.
Hall, C. P., General Elec. Co., Lynn, Mass.
Jeffers, W. M., Crouse-Hinds Co., Syracuse, N. Y.
Len, J. M., General Elec. Co., Pittsfield, Mass.
Mongan, E. J., Bausch & Lomb Optical Co., Rochester, N. Y.
Ottmar, J., Spencer Thermostat Co., Attleboro, Mass.
Perry, F. V., Draper Corp., Hopedale, Mass.
Roth, J. E., Jr., Champlain College, Plattsburg, N. Y.
Suba, M. M., Bakelite Corp., Hartford, Conn.

2. Middle Eastern

Anderson, R. D., Hqtrs. 2nd Army, Engr. Section, Ft. George G. Meade, Md.
Becker, J. A., Westinghouse Elec. Corp., Baltimore, Md.
Blyth, C. R., Hoover Co., North Canton, Ohio
Bushnell, R. H., Hoover Co., North Canton, Ohio
Carter, S. P., Armco Steel Corp., Nellis, W. Va.
DeAnthony, R.P., Wright-Patterson AFB., Dayton, Ohio
Dilles, A. F., United Engineers & Constructors, Philadelphia, Pa.
Duc, J. M., % French Air Attache, Washington, D. C.
Heard, J. T., Jr., Westinghouse Elec. Corp., Lima, Ohio
Henry, E. N., Westinghouse Elec. Corp., Sharon, Pa.
Hunter, L. E., Pangborn Elec. Const. Co., Philadelphia, Pa.
Kelsey, P. C., Appalachian Elec. Power Co., Huntington, W. Va.
Kershaw, A. F., Potomac Elec. Power Co., Washington, D. C.
Leppla, R. J., Jack & Heintz Precision Industry, Bedford, Ohio
Lloyd, J. W., Conestoga Tel & Tel Co., Birdsboro, Pa.
Meehan, F. J., The Elec. Storage Battery Co., Philadelphia, Pa.
Mott, O. B., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Pharis, A. H., General Elec. Co., Philadelphia, Pa.
Rothbard, L., United Engineers & Constructors, Inc., Philadelphia, Pa.
Ruth, B. W., Locke Inc., Baltimore, Md.
Sampson, J. D., Hobart Brothers Co., Troy, Ohio
Schach, M., U. S. Naval Research Lab., Washington, D. C.
Schrader, L. G., Westinghouse Elec. Supply Co., Baltimore, Md.
Siddlarz, J. B., Jr., Bell Tel. Co. of Pa., Pittsburgh, Pa.
Silver, B., Drexel Inst., Philadelphia, Pa.
Springer, E. R., Northern Pennsylvania Power Co., Towanda, Pa.
Tandy, R. B., Ideal Elec. & Mfg. Co., Mansfield, Ohio
Wanaselja, O., Hoover Co., North Canton, Ohio
Weishaupt, H. E., USAF, Air Materiel Command, Dayton, Ohio

3. New York City

Anderson, B. H., Marcus Transformer Co., Inc., Hillside, N. J.
Byrne, M. (Miss), Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Ekeland, A. M., Gibbs & Cox, Inc., New York, N. Y.
Fagin, S. L., Arma Corp., Brooklyn, N. Y.
Fitch, R. N., American Gas & Elec. Service Corp., New York, N. Y.
Gellen, I., Board of Transportation, New York, N. Y.
Gray, L., Burndy Engg. Co., Bronx, N. Y.
Hediger, F. (re-election), American Technical Inst., Brooklyn, N. Y.
Litkenhaus, R. A., Crocker-Wheeler Elec. Mfg. Co., Ampere, N. J.
Miller, C. W., Jr., Bell Tel. Labs., New York, N. Y.
Weinroth, S., Civil Aeronautics Admin., New York, N. Y.
Young, L., American Gas & Elec. Service Corp., New York, N. Y.

4. Southern

Berney, R. S., Todd-Johnson Dry Docks, Inc., New Orleans, La.
Cox, R. K., Lighting Fixture & Elec. Supply Co., New Orleans, La.
East, R. M., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Garrott, W. L., Univ. of Kentucky, Lexington, Ky.
Glazier, R. C., Reynolds, Smith & Hills, Jacksonville, Fla.
Granholm, A. W., Springs Cotton Mills, Lancaster, S. C.
Irwin, F. L., Georgia Power Co., Atlanta, Ga.
Morton, W. R., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Murphy, J. J., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Soule, A. L., III, New Orleans Public Service Inc., New Orleans, La.
Straley, D. E., General Elec. Co., Birmingham, Ala.
Summitt, J. W., Fla. Power & Light Co., Cocoa, Fla.
Unangst, C. W., General Elec. Co., New Orleans, La.
Williamson, R. A., T. V. A., Chattanooga, Tenn.
Yates, J. E., Light Dept., Town of Salem, Va.

5. Great Lakes

Abrahamse, H. L., Consumers Power Co., Jackson, Mich.
Alday, R. R., 1117 W, Harrison St., Chicago, Ill.
Baird, F. A., Public Service Co. of Northern Ill., Joliet, Ill.
Baird, R. A., Barber-Colman Co., Rockford, Ill.
Brewer, J. D., Northwestern Bell Tel. Co., Des Moines, Iowa
Burnand, L. W., Pioneer Service & Engg. Co., Chicago, Ill.
Dahl, O. F., Pioneer Service & Engg. Co., Chicago, Ill.
Eadie, G. H., Line Material Co., S. Milwaukee, Wis.
Ellis, E. E., Allis Chalmers Mfg. Co., Milwaukee, Wis.
Engel, R. C., George R. Horne & Co., Dearborn, Mich.
Gallagher, E. P., George R. Horne & Co., Dearborn, Mich.
Galos, G. E., Commonwealth Edison Co., Chicago, Ill.
Gerdes, W. R., General Elec. Co., Chicago, Ill.
Hibbard, R. L., Cutler-Hammer Inc., Saginaw, Mich.
Hubbard, E. F., Brown Engg. Co., Des Moines, Iowa
Kasmer, C. M., Sargent & Lundy, Chicago, Ill.
Lameika, A., Consumers Power Co., Jackson, Mich.
Lyall, R. M. (re-election), General Elec. Co., Milwaukee, Wis.
Moen, A. L., General Elec. Co., Milwaukee, Wis.
Saunders, H. O., Jr., Illinois Bell Tel. Co., Chicago, Ill.
Sterling, S., S. Sterling Co., Detroit, Mich.
Taggs, R. R., Harley, Ellington & Day, Detroit, Mich.
Tarr, R. A., General Elec. Co., Milwaukee, Wis.
Tyrakowski, J. S., c/o Mrs. Kupinski, 621 North 40th Ave., W. Duluth, Minn.
Weiss, A. E., Pioneer Service & Engg. Co., Chicago, Ill.
Zimmerman, J. A., Allis-Chalmers Mfg. Co., Milwaukee Wis.
Zolot, A. L., Underwriters' Labs., Inc., Chicago, Ill.

6. North Central

Allbright, R. T., Omaha Public Power Dist., Omaha, Nebr.
Miller, A. D., Public Service Co. of Colorado, Denver, Colo.

7. South West

Austin, L. M., Jr., Southwestern Public Service Co., Plainview, Tex.
Binzel, M. S., Washington Univ., St. Louis, Mo.
Edmundson, R. B., West Texas Utilities, Abilene, Tex.
Elleman, F. S., Smiths Bluff Refinery, Nederland, Tex.
Fernandez, R. N., Industria Electrica de Mexico, S. A. Tlalnepantla, Mex.
Gray, J. F., Central Power & Light Co., Corpus Christi, Tex.
Hicks, H. S., H. N. Roberts & Assocs., Lubbock, Tex.
Lutz, C. W., J. F. Pritchard Engg. Co., Kansas City, Mo.
McFarlin, F. E., Oklahoma A & M College, Stillwater, Okla.
McPherson, J. C., Central Power & Light Co., Corpus Christi, Tex.
Millar, J. G. (re-election), City Public Service Board, San Antonio, Tex.
Mueting, W. J., H. N. Roberts & Assocs., Lubbock, Tex.
Nichols, F., Elec. Service Co., Ft. Smith, Ark.
Presley, J. C., Westinghouse Elec. Corp., Dallas, Tex.
Stewart, W. G., Texas Elec. Service Co., Ft. Worth, Tex.
Stuart, E. F., Interstate Elec. Co., Ft. Smith, Ark.
Webber, H. C., Southwestern Public Service Co., Plainview, Tex.
Zimmerman, M. J., City Public Service Board, San Antonio, Tex.

8. Pacific

Bochman, W. O., General Elec. Co., San Francisco, Calif.
Cowgill, R. M., Westinghouse Corp., Fresno, Calif.
Davis, P. L., San Francisco Naval Shipyard, San Francisco, Calif.
Earl, J. L., Industrial & Commercial Elec. Co., Henderson, Nev.
Eddy, W. H., Standard Products, Inc., Phoenix, Ariz.
Elliott, E. R., Dept. of Water & Power, City of Los Angeles, Calif.
Griffin, F. M., Todd Shipyards Corp., San Pedro, Calif.
Irons, V. H., Jr., Pacific Gas & Elec. Co., San Francisco, Calif.
Jennings, J. S., Electrical Distributors Co., San Jose, Calif.
Lovick, E., Jr., Douglas Aircraft Corp., Santa Monica, Calif.
McCraney, J. M., California Public Utility Comm., San Francisco, Calif.
Morken, D. J., Sacramento Municipal Utility Dist., Sacramento, Calif.
Oaks, E. L., Wagner Elec. Corp., San Francisco, Calif.
Sherard, D., Southern California Edison Co., Vernon, Calif.
Vasquez, A., Leach Relay Co., Los Angeles, Calif.
Wood, A. M., Littelfuse Inc., El Monte, Calif.

9. North West

Britton, R. B., General Elec. Co., Richland, Wash.
Mitchell, M. R., Newbery-Neon Joint Venture, Richland, Wash.
Rhodes, J. H. (re-election), Giffels & Vallet, Richland, Wash.
Singer, G. H., Jr., Boeing Airplane Co., Seattle, Wash.
Sipple, W. A., Western Electrical Const. Co., Portland, Oreg.
Sisk, J. E., General Elec. Co., Richland, Wash.

10. Canada

Beattie, F. N., Sangamo Co. Ltd., Montreal, Quebec, Canada
Brown, W. D., Hydro-Elec. Power Comm. of Ontario, Niagara Falls, Ontario, Canada
Dickson, F. N., Amalgamated Elec. Corp. Ltd., Toronto, Ontario, Canada
Dougherty, L. G., Eastern Power Devices, Montreal, Quebec, Canada
Lappi, D. M., Northern Elec. Co., Ltd., Montreal, Quebec, Canada
MacKay, R. P., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
McCall, L. V., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Mincoff, E., Orillia Power Co., Hydro Glen., Ontario, Canada
Naylor, R. W., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Noad, A. J., Stadler, Hurter & Co., Montreal, Quebec, Canada
Ransom, G. E., Beauharnois Light, Heat & Power Co., Beauharnois, Quebec, Canada
Sinnott, J. P., Hydro Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Smith, A. T., Hamilton Hydro Elec. System, Hamilton, Ontario, Canada
Vrooman, C. R., Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada

Elsewhere

Byrne, P. J., Electricity Supply Board, Dublin, Ireland
Casavecchia, S., Ercole Marelli & Co., Milan, Italy
El-Kholi, M. M., Government Workshops, Boulac, Cairo, Egypt
Fairclough, F. R., British Broadcasting Corp., London, England
Lall, W. G., (Gov't. of India) 5 Scotch Corner, Lahore, Pakistan
Law, B. D., Matchwell Electricals (India), Ltd., Delhi, India
Rathsman, B. G., State Power Board, Stockholm, Sweden
Saund, S. S., The Sikar Elec. Supply Co. Ltd., Sikar, Rajputana, India
Scott, J. K., Canterbury University College, D.S.I.R., Christchurch, New Zealand
Sibley, E. H., Faraday House College, London, England
Williams, N. E., Hopkinson Elec. Co. Ltd., Whitchurch, Cardiff, Wales

Total to grade of Associate

United States, Canada, and Mexico, 163
Elsewhere, 11

OF CURRENT INTEREST

US-Britain-Canada Agree on Standards for Screw Threads

A joint conference of representatives of Government committees and ranking industrial standardization groups from Great Britain, Canada, and the United States are scheduled to meet within the next three months to finalize agreements on common standards for screw threads used on most types of threaded fasteners, including bolts and nuts. The attainment of such standards is important to commerce and industry. It is planned to hold this conference at the National Bureau of Standards, which has actively co-operated in the attainment of this objective over a period of many years. These agreements will not be in the form of a treaty, but will be based on separate documents, each of which is sponsored by the standardization group or groups of each of the countries concerned. These documents, setting forth the Unified Screw Thread Standard, will be in agreement on all fundamental points relating to the standard, but may differ in minor details and will differ in arrangement and general makeup. The purposes of the joint conference are to assure that there is complete agreement on all fundamentals and to celebrate the attainment of such agreement after many years of negotiations.

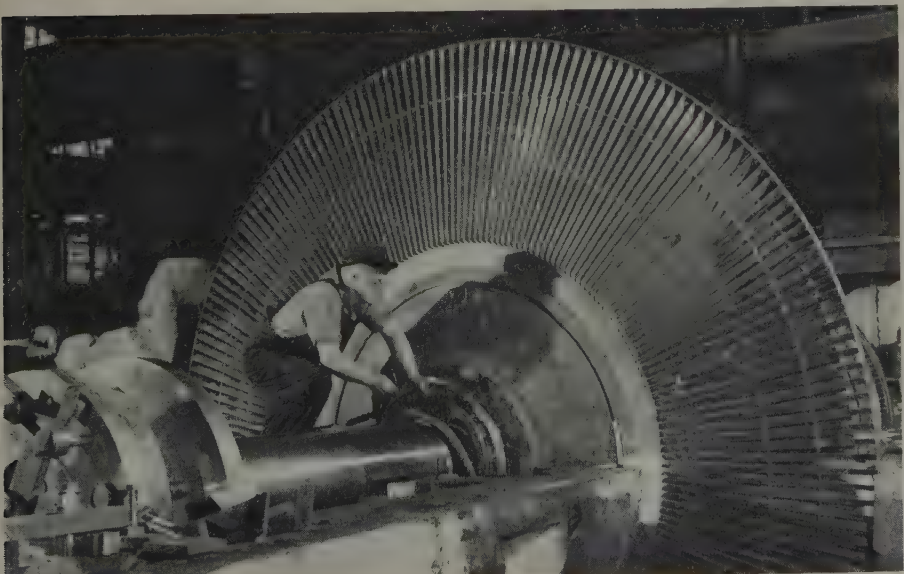
On the American side there will be two documents, one of which will be the Proposed American Standard for Unified Screw Threads prepared by the Sectional Committee on the Standardization and Unification of Screw Threads, and will represent the agreement on unified screw threads by American industry. The second document will present the standard as adopted by the Interdepartmental Screw Thread Committee (successor to the National Screw Thread Commission), composed of members of the Departments of the Army, Navy, Air Force, and Commerce, and will represent the agreement on unified screw threads of those departments of the federal government most concerned with screw threads.

The Unified Screw Thread Standard was formulated in five major and several informal conferences of representatives of the countries concerned. In July 1918, the Congress of the United States authorized the appointment of the National Screw Thread Commission, with the director of the National Bureau of Standards as chairman, to investigate and promulgate standards for screw threads. One year later, and after a thorough study of screw thread practice in the United States, the commission conferred with British and French engineers and manufacturers of screw thread products, for the purpose of discussing the tentative report which it had prepared with the hope that it might serve as a basis for international standardization. No definite agreements were reached, but the need for continued study was recognized.

In 1926, a further attempt was made to unify the British Standard Whitworth Thread, having an angle of 55 degrees and the American National Thread, having an angle of 60 degrees, when a British mission visited the United States and proposed a basic thread angle of $57^1/_2$ degrees. The compromise was not considered acceptable. In 1943, a British mission visited the United States, at the invitation of the Combined Production and Resources Board, and Canadian representatives also were invited to participate in the discussion, in which notable progress was made on projects of immediate concern. In August–September 1944, a joint United States-Canadian group, sent to London by the same board, conferred with committees of the British Standards Institution.

In September–October 1945, under the auspices of the same board, a conference on unification of engineering standards was held in Ottawa, Ontario, Canada. At this conference a unified form of thread having a 60-degree angle, together with standard sizes and pitches, was agreed upon. Thus the foundation was laid for the standards to be agreed on, but a vast amount of work remained to be done in developing and agreeing upon classes or grades of fit and corresponding tolerances and allowances. When a small British delegation visited the United States in July 1948, basic mathematical formulas for such tolerances and allowances were tentatively agreed upon and later ratified by correspondence, thus making possible the completion of the standards which it is hoped will be agreed upon at the November 1948 meeting.

Los Angeles Turbine Tested



The General Electric turbine plant at Schenectady, N. Y., has completed tests on a new 75,000-kw turbine to be used in the Los Angeles, Calif., area. Shown being installed is the giant rotor weighing approximately 40 tons and more than 12 feet in diameter

Future Meetings of Other Societies

American Institute of Consulting Engineers. Annual meeting, January 5, 1949, 75 West Street, New York, N. Y.

American Society of Heating and Ventilating Engineers. Annual meeting, January 24–27, 1949, Chicago, Ill.

American Society of Photogrammetry. Annual meeting, January 12–14, 1949, Hotel Shoreham, Washington, D. C.

American Society of Refrigerating Engineers. 44th annual meeting, December 5–8, 1948, Washington, D. C.

American Statistical Association. Meeting, December 27–29, 1948, Hotel Statler, Cleveland, Ohio.

Institute of Mathematical Statistics. Meeting, December 27–30, 1948, Hotel Statler, Cleveland, Ohio.

Materials Handling Show. Third annual. January 10–14, 1949, Convention Hall, Philadelphia, Pa.

Mathematical Association of America. Annual meeting, December 31, 1948, Ohio State University, Columbus, Ohio.

National Society of Professional Engineers. December 5–8, 1948, Hotel Sherman, Chicago, Ill.

Radiological Society of North America, Inc. December 5–10, 1948, Hotels Fairmont and Mark Hopkins, San Francisco, Calif.

Society of Automotive Engineers. January 10–14, 1949, Book-Cadillac Hotel, Detroit, Mich.

Southwestern Institute of Radio Engineers Conference. December 10–11, 1948. Baker Hotel, Dallas, Tex.

New Rotary Dial System Installed in Rochester

Another milestone in the progress of independent telephony in the United States was reached at midnight, August 27, when the Rochester Telephone Corporation, the the second largest independent company in the country, successfully accomplished the first of a series of cutovers in the ultimate conversion to dial service of the entire multioffice network in the city of Rochester, N. Y.

The initial cutover, involving 8,716 lines and 13,669 main stations out of totals of 18,400 lines and 28,400 terminals installed, gave to Rochester the distinction of being the first city in the United States to place in operation the *7A-2* rotary dial switching system manufactured by Federal Telephone and Radio Corporation, associate of the International Telephone and Telegraph Corporation (*see EE, July '48, p 646*). This conversion, which inaugurated the Rochester Telephone Corporation's new Baker and Hamilton exchanges, was the largest initial cutover from manual to dial operation made by an independent telephone company in many years.

The second step under the corporation's city-wide conversion program calls for the transfer, at the close of the year, of all Main pay station lines to the new Empire rotary unit. The final step of the first group of three cutovers will be the transfer of all remaining Main manual subscribers to the Locust rotary exchange. Former Stone and Main subscribers now enjoying dial service include the principal shopping and banking district in the heart of the city of Rochester as well as many leading industrial firms. The remainder of the local central offices will be converted to dial operation as rapidly as practical. At the present time the local multioffice network comprises 50,060 lines and 131,632 stations.

Rochester's rotary installation was designed by engineers of the telephone company, Federal Telephone and Radio Corporation, and International Telephone and Telegraph Corporation to meet the city's specific requirements, such as: the provision for swift and accurate interconnection of manual and dial central offices during the period of conversion, the subsequent integration of the system through intercentral office automatic trunking, the efficient handling of Rochester's exceptionally high percentage of 2-, 4-, and 8-party lines. In solving these and others of Rochester's special operating problems, many new and important technical improvements were incorporated in the *7A-2* rotary system installed by the Federal Corporation.

Rochester's *7A-2* dial system is a power-driven system that utilizes finder, selector, and sequence switches and flat type relays, grouped in various combinations and mounted on bay. These bays, in turn, are mounted in switch racks and arranged in 2,000-line groups.

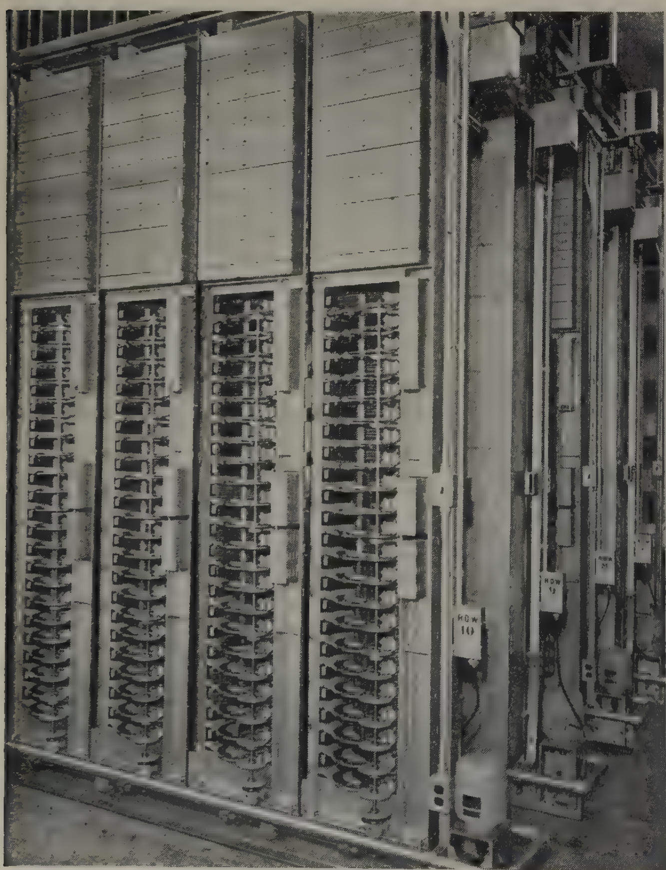
An important feature of the system is the positive control of selection, whereby the selector switches transmit revertive pulses to the register as to their position and stage of operation, and also receive controlling signals from the register. Another important feature of the system for a city the size of Rochester is its method of doubling-up trunk groups. With this system a 10,000-line office can be served over only five levels of third group selectors.

The Rochester installation includes a 14-position dial service assistance board, of which two positions are for the official PABX; a 4-position wire chief's test panel; a 2-position repair clerk's desk; and a centralized observation desk. It also includes a special toll register designed to interwork with Bell System 6-frequency key pulsing and nationwide toll operator dialing. This is the first installation of this type of dialing to be placed in service by an independent telephone company. Other features are a controlled ringing toll train for the Rochester Telephone Corporation's DSA board, and circuits to permit the use of special nonmetering lines to the police and fire departments.

The corporation's official *7J* PABX, a new Federal development which permits the official, or company, stations to dial any telephone in the Rochester area, is designed to work with the Rochester rotary system. This PABX utilized a simple line finder type of switch for all switching functions.

The telephone numbering scheme of the Rochester installation permits office subscribers to dial not only other dial subscribers' numbers, but the complete telephone numbers of subscribers in manual offices. No changes in present manual office telephone numbers are required.

Initial development of the rotary-type dial equipment was begun in 1904 by the engineering department of the Western Electric Company, predecessor of Bell Laboratories. When International Western Electric Company was sold to International Telephone and Telegraph Corporation after World War I, development of the rotary system was continued to bring it to its present stage of high perfection. While the system is new to the United States, it long has been standard with International Telephone and Telegraph Corporation and other operating companies throughout the world.



Partial view of the "first line finder bays," part of the new *7A-2* rotary dial switching system installed by the Federal Telephone and Radio Corporation for the Rochester Telephone Corporation

Contract Made for Pacific Steam-Electric Generating Plant

A contract for the engineering and construction of one of the largest steam-electric generating stations ever built has been awarded by the Pacific Gas and Electric Company to the Bechtel Corporation of San Francisco, Calif.

The plant will be located on the San Joaquin river frontage two miles east of Antioch, in central California, and will cost $51,500,000.

When complete, the new station will furnish 400,000 of the total 2,000,000 horsepower the company is adding to its system. Electric power will be produced by three turbine-driven 100,000-kw generators. The station will be equipped to burn either gas or oil, and equipment will be built and spaced to permit addition of coal-burning facilities.

Detailed designs and specifications are being made and field construction will begin in 1949.

The construction engineers estimate completion sometime in 1951.

Million Words a Minute Transmitted by "Ultrafax"

Ultrafax, a newly developed system of television communications capable of transmitting and receiving written or printed messages and documents at the rate of a million words a minute, was demonstrated publicly for the first time by the Radio Corporation of America at the Library of Congress on October 21. The process, which splits the seconds and utilizes each fraction for high-speed transmission of intelligence, is as significant a milestone in communications as was the splitting of the atom in the world of energy, it is thought.

Among the possible developments were

1. The exchange of international television programs achieved on a transoceanic basis.
2. A service of television and Ultrafax by which the same receiving set would bring various types of publications into the home, or a newspaper for that matter, without interrupting the program being viewed.
3. A system of world-wide military communications for the United States, scrambled to the needs of secrecy, which with ten transmitters could carry in 60 seconds the peak load of message traffic cleared from the Pentagon Building in 24 hours during World War II.
4. The establishment of great newspapers as national institutions, by instantaneous transmission and reception of complete editions into every home equipped with a television set.
5. The transmission of a full-length motion picture from a single negative in the production studio simultaneously to the screens of thousands of motion picture theaters throughout the country.
6. The possibility of a new radio-mail system with the vast pickup and delivery services of the Post Office Department.

Representatives of the United States Armed Forces, Government agencies, industry, and the press witnessed the introduction of this advanced communications system. The demonstration proved the ability of Ultrafax to transmit at the speed of light—186,000 miles a second—a wide variety of graphic material including charts, fingerprints, news, and advertising layouts and items ranging from historical documents to complex atomic formulas and battle maps. A striking feature of the demonstration came when the 1,047-page novel "Gone With the Wind" was transmitted word for word in its entirety in about two minutes from the transmitter to the receiver in the Library of Congress.

The Ultrafax system, RCA engineers reported, combines the elements of television with the latest techniques in radio-relaying and high-speed photography. The system is a development of RCA Laboratories, in co-operation with the Eastman Kodak Company and the National Broadcasting Company. Engineers stated that the radio-television-photography combination forms the basis for a system of graphic communication which can be extended city to city nation-wide.

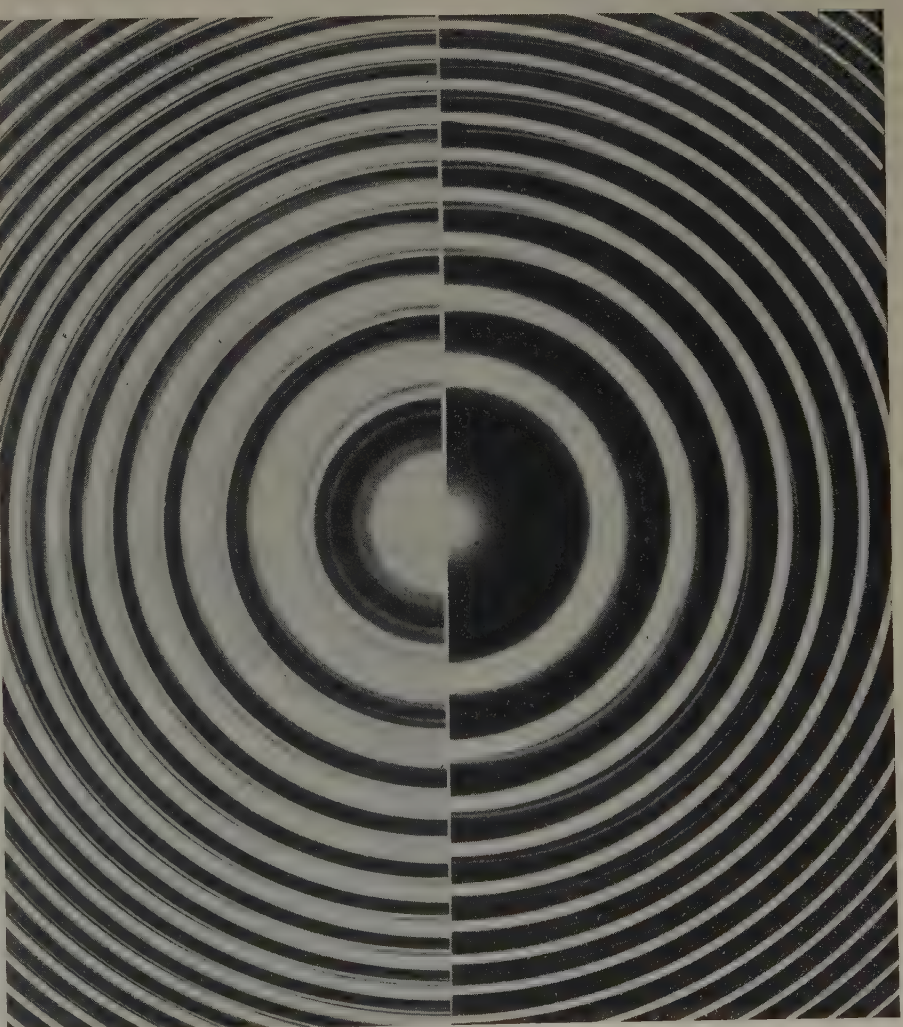
Ultrafax's remarkable speed is possible because full pages of information are transmitted as television pictures at the rate of 15 to 30 a second. The principal steps in transmitting and receiving by Ultrafax are

1. Preparation of data to be transmitted, to assure a continuous flow at high speed.
2. Scanning of these data by what is known as a flying-spot television scanner, at the sending terminal.
3. Transmission of the television image as ultrahigh radio-frequency signals over a microwave relay system.
4. Reception on projection-type television kinescope, or "picture tube," from which incoming messages are recorded on motion picture film, or ultimately directly onto photographic paper.

At the end of a transmission, the exposed film can be transferred quickly to a special processing unit developed by Kodak Research Laboratories. The film is passed through a miniature developing tank, rinsed, and fixed in less than 15 seconds and dried in 25 seconds more. The Ultrafax film may be enlarged to full-sized copy by means of a high-speed continuous processing machine. The equipment is similar to that used during the war for V-mail enlarging. There is no limit to the number of Ultrafax messages which may be printed from a single film.

Allen Receives John Fritz Medal. The John Fritz Medal Award Board has announced that Charles Metcalf Allen, professor of hydraulic engineering at Worcester Polytechnic Institute and director of the Alden Hydraulic Laboratory, Worcester, Mass., has been selected to receive the 1949 John Fritz Medal for scientific achievement. Professor Allen was cited "for exceptional achievement in hydraulic engineering and as the founder of a notable hydraulic laboratory; prominent teacher, consultant, inventor, and author." Doctor Allen holds an honorary membership in The American Society of Mechanical Engineers, of which he was vice-president in 1931–33. He is also a member of the American Society of Civil Engineers, the Society for the Promotion of Engineering Education, and the American Association for the Advancement of Science. He is a past president of the Boston Society of Civil Engineers.

Prize-Winning AAAS Science Photo



This photograph of interference fringes formed by the green radiation of mercury compares those of natural mercury (left) and mercury 198 (right), a stable isotope made by bombarding gold with neutrons in an atomic pile. The wave length of the isotope provides a new and better standard of length since its spectral line represents the ultimate in sharpness and intensity that can be obtained from any atom, either naturally or artificially. Wave lengths now have been measured with an accuracy of one part in a hundred million. The photograph was awarded first prize in the Second Photograph-in-Science Salon of the American Association for the Advancement of Science, in September 1948

Applications Accepted for GE Graduate Grants

Applications are being accepted for research grants under the $1,000,000 General Electric Education Fund for the scholastic year of 1949–50. For the 25th consecutive year, aid in grants up to $1,500 annually will be awarded to college graduates who wish to continue individual study and research in scientific and industrial fields.

The General Electric Education Fund was established in 1945 honoring two former General Electric presidents, Charles A. Coffin and Gerard Swope. The Charles A. Coffin Fellowships are awarded in the fields of electricity, physics, and physical chemistry, with particular attention given the research problems of each applicant. Some 175 persons have been awarded the Coffin Fellowship since 1923. The Gerard Swope Fellowships, founded in 1946, are awarded in the fields of industrial management, engineering, the physical sciences, and any other scientific or industrial field. Some 19 persons have been awarded the Swope Fellowship.

Fellowships are intended for graduates who need financial assistance, and who have shown by the character of their work that they could undertake or continue research, with advantage, in the United States or abroad. A committee representing the National Academy of Sciences, American Chemical Society, American Physical Society, AIEE, The American Society of Mechanical Engineers, and the American Society of Engineering Education, will pass upon all candidates for the fellowships.

Applications for the fellowships, which must be filed by January 1, 1949, have been distributed to libraries of engineering schools; department heads of electrical and mechanical engineering schools; professors of electrical and mechanical engineering, physics, chemistry, and metallurgy; and deans of graduate schools. Applications must be mailed to the Secretary, General Electric Company Education Fund, Schenectady, N. Y.

Eta Kappa Nu Prepares for 1948 Recognition Awards

Eta Kappa Nu (HKN), national honorary electrical engineering society, will present its recognition award for 1948 to the outstanding young electrical engineer selected by the Eta Kappa Nu jury of awards on the first evening of the AIEE winter general meeting, to be held in New York, N. Y., January 31 to February 4, 1949.

This award was established by Eta Kappa Nu in 1936 to recognize "meritorious service in the interest of their fellow men" on the part of young electrical engineers, not only for their technical ability and accomplishments already achieved, but also for their interest in cultural and civic advancement and their promise for future development.

To qualify for the award, candidates must be not older than 35 years nor be out of college for more than 10 years by May 1 of the year for which cited. They are nominated by Sections of the AIEE, by faculty members of engineering colleges, and by key men in the electrical industry.

The name of each award winner is engraved on a bronze bowl, on public display at AIEE headquarters in New York, N. Y., and the recipient is given a miniature replica. Honorable mention winners are tendered certificates by the society.

Final selection of candidates is made by a jury of awards composed of well-known engineers from industry and educational institutions on the basis of the candidate's accomplishments in technical, professional, and social fields. At the time this issue of *ELECTRICAL ENGINEERING* goes to press, the 1948 jury is being selected by the society.

Presentations were made annually for each year from 1936 to, and including, 1941. Winners for those years, with their affiliation at the time of the award, included:

- 1936—Frank M. Starr, General Electric Company, Schenectady, N. Y.
- 1937—C. G. Suits, General Electric Company, Schenectady, N. Y.
- 1938—Winston E. Kock, Baldwin Piano Company, Cincinnati, Ohio
- 1939—L. A. Meacham, Bell Telephone Laboratories Inc., New York, N. Y.
- 1940—Jesse E. Hobson, Westinghouse Electric Corporation, East Pittsburgh, Pa.
- 1941—Cledo Brunetti, Lehigh University, Bethlehem, Pa.

Suspended during the war, Eta Kappa Nu resumed the awards again by presenting six of them for the years 1942–47 at the 1948 AIEE winter general meeting. These were the recipients and the year in which they won the award, together with their affiliation at that time:

- 1942—John R. Pierce, Bell Telephone Laboratories, Inc., New York, N. Y.
- 1943—Nathan I. Hall, Hughes Aircraft Company, Culver City, Calif.
- 1944—Richard W. Porter, General Electric Company, Schenectady, N. Y.
- 1945—James M. Wallace, Westinghouse Electric Corporation, Pittsburgh, Pa.
- 1946—Everard M. Williams, Carnegie Institute of Technology, Pittsburgh, Pa.
- 1947—Richard M. Hough, Bell Telephone Laboratories, Inc., Whippany, N. J.

Sir Clifford Paterson Awarded 1948 IES Medal

Because of his serious illness, Sir Clifford Paterson was presented the Illuminating Engineering Society's Medal for 1948 at his home in Hertsfordshire, England, on July 22, rather than at the society's annual conference. The presentation was made to Mrs. Paterson, four days prior to Sir Clifford's death on the 26th, by Preston S. Millar, official IES delegate.

Paterson was well-known for the notable improvements made in precision methods of measuring light and for work done in establishing the International Light Standard under him while he was head of the electrotechnical and photometric departments of the National Physical Laboratory from 1903 to 1919. During World War I, he helped develop the Paterson-Walsh device for automatic estimation of the height of aircraft, and from 1919 until his death, was director of research laboratories planning for General Electric, Ltd. He was conferred a Knight in 1946.

Paterson was a past president of the International Commission on Illumination, and also both the Illuminating Engineering Society and the Institution of Electrical Engineers of Great Britain. In World War II, he was a member of the Advisory Council of Scientific and Industrial Research as an authority on lighting subjects.

EJC Welcomes Brazilians

The committee on international relations of the Engineers Joint Council was host to engineers from Brazil at a recent EJC meeting. Shown being welcomed are Armando de A. Pereira (center left), president of the Manufacturers Association of Sao Paulo, and Argemiro Couto de Barros (center right), president of the Engineers Institute of Sao Paulo, by General Stewart E. Reimel (left), secretary and L. W. Bass (right), chairman of EJC

Joel D. Justin Elected Engineering Foundation Head

The Engineering Foundation, 29 East 39th Street, New York, N. Y., has announced the election of Joel D. Justin, consulting engineer of Philadelphia, Pa., as chairman and as chairman of the executive committee. Doctor Boris A. Bakhmeteff, consulting engineer and professor of civil engineering, Columbia University, was chosen vice-chairman. Doctor Edwin H. Colpitts, formerly vice-president of the Bell Telephone Laboratories, was re-elected director and John H. R. Arms was re-elected secretary.

To continue as members of the executive committee will be: Doctor O. E. Buckley, president of the Bell Telephone Laboratories; Doctor A. B. Kinzel, vice-president of the Union Carbide and Carbon Research Laboratories, Inc.; R. H. Chambers, former vice-president and consulting engineer of the Foundation Company. Mr. Arms will be secretary for the committee.

The Engineering Foundation has been engaged in important research activities for more than 31 years. It aided in establishing the National Research Council, and its division of engineering and industrial research. It has contributed to the support of the Engineers' Council for Professional Development, which aims at the advancement of the engineering profession. The foundation also has supported engineering research and investigations in varied fields. During the past year, it has aided 18 research projects in such varied fields as hydraulics, alloys of iron, properties of gases, welding, riveted and bolted structural joints, and properties of metals at different temperatures.

ASCE Honors General Clay. General Lucius D. Clay, commander-in-chief of American Forces in Europe, is among five eminent engineers who have been elected to Honorary Membership, highest award of the American Society of Civil Engineers. Other recipients include: C. H. Buford, president, Chicago, Milwaukee, St. Paul and Pacific Railroad, an authority on railroad operation and engineering economics; Professor Donald Derickson, retired head of Tulane University's civil engineering school and author of college texts; Gano Dunn, president, J. G. White Engineering Corporation, New York, N. Y., engineer and industrialist and recipient of the Edison, Hoover, and Egleston Medals; Andrew Weiss, consulting engineer, Mexican National Commission of Irrigation, prominent reclamation engineer. The awards will be made at ceremonies during the ASCE's annual meeting in New York City, January 19, 1949.

AES Fellowship Established. The research committee of the American Electroplaters' Society has announced the establishment of a second fellowship at Princeton University to intensify the study of the nature and effects of porosity in electrodeposits. The first fellowship, established in 1946, already has developed an unique and original method for studying porosity by stripping the base metal and measuring its permeability to a gas. The project is under the direction of Doctor Nathaniel Thon, with the assistance of Doctor L. Yang. Members of the project directing committee include Doctor W. A. Wesley, chairman of the International Nickel Company, A. Mendizza of the Bell Telephone Laboratories, and Doctor B. Egeberg of the International Silver Company.

Thomas Elected President as ASCE Holds Fall Meeting

Franklin Thomas, professor of civil engineering and dean of students at the California Institute of Technology, Pasadena, Calif., was nominated without opposition as the 1949 president of the American Society of Civil Engineers at the fall meeting of the Society. The 3-day meeting was held at the Hotel Statler, Boston, Mass., beginning Wednesday, October 13, 1948. Confirmation of the nomination will be by letter ballot of the membership later this year.

Dean Thomas was a director of ASCE in 1930–33, and a vice-president in 1944–45. He recently was appointed chairman of the Colorado River Board of California by Governor Earl Warren, and long has been active in civic affairs.

The fall meeting, held in Boston as part of the centennial celebration of the Boston Society of Civil Engineers, oldest engineering unit in the United States, was attended by 800 civil engineers and representatives from 14 New England student chapters. Featured in the nine technical sessions were traffic and city planning, construction costs control, air transport, and other subjects affecting the northeastern section of the United States.

Berkey Receives First Kemp Medal. President Dwight D. Eisenhower of Columbia University presented the first Kemp Medal "for distinguished service in geology," to Doctor Charles P. Berkey, Newberry professor emeritus of geology, at a testimonial dinner October 26, at the Columbia University Men's Faculty Club. The award, made in the presence of leading scientists and executives in major geological fields, was established a year ago in honor of the late James Furman Kemp, founder of the geology department and a pioneer in the field of engineering geology. The recipient, Doctor Berkey, has served as consultant for some of the major engineering projects of this century, and is known as the man who knows more about New York's bridges, tunnels, and foundations than any man alive.

Robertson Takes Naval Research Post. Doctor Randall M. Robertson, specialist in electronics and solid state physics, has been appointed acting director of the physical sciences division of the Office of Naval Research. He will fill the vacancy left by Doctor Emanuel R. Piore who was granted a year's leave of absence to do research at the Massachusetts Institute of Technology. Doctor Robertson received his master of arts degree from the University of Glasgow, Scotland, in 1932, and his doctorate in physics from the Massachusetts Institute of Technology in 1936. During the second World War, he did research on air-borne radar at the MIT radiation laboratory, and in 1946, joined the scientific staff of the office of Naval Research as head of the mechanics and materials branch.

Bennett to Head Standards Section. Doctor Willard H. Bennett has been designated head of the physical electronics section of the atomic and molecular physics division of the National Bureau of Standards, where he will be actively engaged in basic research on cathode emission processes and the physical properties of negative atomic ions. He is responsible for the recently developed radio-frequency mass spectrometer tube and assisted in the early development of a gas-filled cold-cathode rectifier. Before joining the bureau staff in 1946, Doctor Bennett was director of physical and applied research at the Institute of Textile Technology, following three years as a major with the Signal Corps in the Pacific theater. Author of numerous technical and scientific papers, and coauthor of a college physics text, Bennett is also a fellow of the American Physical Society, and a member of both the American Association of University Professors and Sigma Xi fraternity.

Cohen, Radio Expert, Dies. Louis Cohen, engineer consultant and inventor of many devices in radio and cable telegraphy, died September 28, 1948. He had been with the Bureau of Standards since 1905, and was internationally known for his radio and telegraphic researches, as well as for numerous devices he helped develop. A graduate of the University of Chicago, he received his doctorate from Columbia University in 1905. In 1921, he was a United States delegate to the International Conference on Electrical Communications at Paris, and served as a technical expert with the German-Austrian Claim Commission from 1929 to 1931. He had written several technical books and papers on the general field of electricity.

Sieger Elected AWS President. The American Welding Society has elected George W. Sieger, president of the S-M-S Corporation of Detroit, Mich., as its president for the year 1948–49. He was installed at the society's annual meeting at Philadelphia, Pa., during the week of October 24, 1948. A national authority on resistance welding, Sieger is a past president of the Resistance Welding Manufacturers Association and a member of resistance welding committees of the War Production Board during World War II. He was first vice-president of the American Welding Society in 1947–48, and also holds membership in the American Society for Metals and the Society of Automotive Engineers.

Three Receive Medals Awarded by AIME

The American Institute of Mining and Metallurgical Engineers has announced the awarding of three medals, one posthumously, for distinguished achievement in mining and metallurgy.

Recipient of the James Douglas Gold Medal for 1949 is William Wraith, consultant engineer for the Andes Copper Mining Company, Chile Exploration Company, Inspiration Consolidated Copper Company, and the Greene Cananea Copper Company, and former AIME executive vice-president. The medal was awarded for "conspicuous leadership in and fundamental contribution to technologic progress in the arts of bene-

fitiating ores of nonferrous metals, especially chose of copper."

The posthumous award of the Charles F. Rand Medal for 1949 was made to Harry Carothers Wiess, president of the Humble Oil and Refining Company for "energy, wisdom, and administrative ability which found expression in major contributions to the economy of the nation and the world; for high courage and vision in services to the petroleum industry; for ceaseless efforts in fostering during World War II the production of strategic supplies; for a greatness of character which showed itself in his many philanthropies and in the respect of all who knew him." Wiess is the fourth Rand Medalist.

For distinguished achievement in mining, the W. L. Saunders Medal for 1949 was given to Stanly A. Easton, president of the Bunker Hill and Sullivan Mining and Concentration Company. He was cited for "his leadership over a period of 50 years in the development of the Bunker Hill and Sullivan, one of the great mining enterprises of the world." This company is one of the world's largest lead and silver mining companies.

Scientists Form Committee on Loyalty Problems

Formation of a "Scientists' Committee on Loyalty Problems" has been announced by the Federation of American Scientists. This committee, with offices in Princeton, N. J., will provide information and legal advice to individual scientists faced with clearance problems, and will try to bring about a clearer public understanding of the issues involved. The committee will not "defend" scientists under investigation but will seek to obtain full and fair hearings by government agencies and Congressional committees, and fair treatment in the press.

It will co-operate with individuals and organizations with similar aims, and will set up a panel of sponsors and consultants on major policy questions. A fund raising campaign is being conducted to obtain contributions from scientists and the general public. At present, its membership includes numerous prominent and distinguished scientists and educators.

The committee program includes a study of clearance procedures and criteria for judging loyalty. A file on such related matters will be maintained, and will be based on public and official sources. By making available information on the issues underlying security and clearance problems, the committee hopes to combat unsubstantiated public defamation of scientists.

Bell Labs Get New Quarters. Bell Telephone Laboratories has announced the initial occupancy of the second building unit at the Murray Hill, N. J., telephone research installation. Full occupancy by 2,300 scientists and engineers is expected by the end of 1949. The second building adds 250,000 square feet of working floor space to the 200,000 square feet in use in the first building since 1942. Part of the new addition is a one-story building with 30,000 square feet of floor space to be used for installation of large laboratory apparatus. Movable steel walls within the building itself will allow overnight floor plan changes.

Tau Beta Pi Fraternity Holds 43d Annual Convention

The 43d convention of Tau Beta Pi was held in Austin, Tex., October 14, 15, and 16, 1948. Undergraduate student delegates from 82 chapters of the society attended, along with the national officers of the association headed by President Merton M. Cory, professor of electrical engineering at Michigan State College. The Texas Alpha chapter of Tau Beta Pi, located at the University of Texas, was host for the 3-day meeting.

Major speakers at the various convention banquets included Governor Beauford H. Jester of Texas, President T. S. Painter of the University of Texas, William J. Murray, Jr., Railroad Commissioner of Texas, and Doctor Harvey M. Merker, superintendent of manufacturing for Parke, Davis and Company, Detroit, Mich., a national councillor of Tau Beta Pi. Other social functions enjoyed by the delegates included an outdoor barbeque and smoker, a semiformal dance, and the Texas-Arkansas football game.

Business sessions of the convention were presided over by Professor A. D. Moore of the University of Michigan, a past president of Tau Beta Pi. The conclave once again defeated efforts to permit the admittance of women to full membership in the association in spite of an excellently prepared case in their favor. (The association will continue to award special Women's Badges to girls in engineering who may be selected for the honor by undergraduate chapters. Eighty-five women have received the badge over the past 25 years.)

The convention granted Tau Beta Pi's 84th active chapter to petitioning students at the University of Connecticut, and the new chapter will be installed in January 1949. The next annual convention will be held at Purdue University, West Lafayette, Ind., in October 1949, with the Indiana Alpha chapter as hosts.

GE Resumes Research on Lightning in New York City

Scientists of the General Electric Company have begun their eighth summer of lightning research at New York's Empire State Building. Complete photographic records and electrical measurements are being obtained on all lightning strokes striking the National Broadcasting Company's antenna atop the building, throughout the summer.

A continuation of research begun in 1935 by Doctor Karl B. McEachron (F '37), this summer's expedition is headed by Julius H. Hagenguth (M '44) engineer in charge of the General Electric high-voltage laboratory at Pittsfield, Mass. John Alger, student engineer from Massachusetts Institute of Technology, is the General Electric operator installing the equipment and gathering the lightning information.

By addition of new photographic equipment strategically located and improvements on sensitive recording devices, the engineers expect to determine the exact currents in each lightning stroke, the length of time each stroke lasts, the intensity of the light produced by the lightning bolt, and the physical shape or path of the stroke. A heavy copper cable extending through the interior of the National Broadcasting Company antenna atop the building receives the lightning impulses and carries them to oscillographs in the attic of the Empire State Building, where the currents and time lengths are recorded. Simultaneously, photographs of each stroke are taken from two different locations at right angles to the building. This permits obtaining a 3-dimensional view of the stroke and determining its exact length.

An automatic corona device mounted on the top railing of the building, turns on all recording equipment as storms approach or as storm fields form around the building. This building was chosen because it is struck as many as 12 times during one storm and 48 times during a summer.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Modified Slip Test

To the Editor:

Reference is made to the article, "Modified Slip Test for Experimental Study of Synchronous Reactance," by Henry B. Hansteen, *ELECTRICAL ENGINEERING*, September 1948, pages 890–2.

It may be of interest to mention that the modified slip method was published in the form of mimeographed notes and was in use in the electrical engineering machinery laboratories when the writer joined the staff at the University of California in 1932. From the description of the machines used by Hansteen the writer concludes that the experimental work was done on 15-kva 220-volt 1,200-rpm 3-unit motor-generator set, commonly known as laboratory phase displacement set built by the Westinghouse Electric Corporation. Values of effective a-c resistance, leakage, unsaturated direct and quadrature axis reactance, and curve of saturated quadrature axis reactances obtained from the modified slip test for two such machines are given in my, "Static Power Limits of Synchronous Machines," AIEE technical paper 38-108, July 1938, and published in *ELECTRICAL ENGINEERING*, volume 58, 1939, March section, pages 92–101.

CHARLES F. DALZIEL (M '39)

(Professor of electrical engineering, University of Calif., Berkeley, Calif.)

Voltage Notation Conventions

To the Editor:

In the October 1948 issue of *ELECTRICAL ENGINEERING*, Walter Richter presents his views on the matter of voltage notation conventions (*pp 1028–30*). I certainly agree with him that the basic science committee of the Institute could render a service by studying the matter and making recommendations to the membership.

In his letter, Mr. Richter comments that the necessity for the two symbols **V** and **E** is beyond his comprehension. In some branches of electrical engineering there probably is little or no necessity for the two, but, in other branches of the art, we need the two to help us keep our ideas clear. **V** is the generic term and may be used for any voltage whatsoever, including the **E's**. **E** is a voltage which is independent of the current. It is a voltage source. It is a voltage with zero regulation

Such a voltage is the open circuit voltage used as the **E** in Thevenin's theorem, when we represent a part of a network by an **E** in series with an impedance. In network analysis, it is most useful to have a symbol to represent these voltages which are independent of the current.

At the risk of spoiling my case for **E**, I would like to suggest, for use in network analysis, a special symbol to represent a current source, which is a current which remains constant independently of the voltage. As a symbol, I suggest **A**. Then **I** is the generic term for all currents, and **A** is a special term for those currents whose value is independent of the voltage. Such a current is the current source in Norton's theorem, which is the dual of Thevenin's theorem.

For simple circuits we probably do not need either the voltage source or the current source for our calculations, but it has been my experience that their usefulness in circuit analysis increases with the complexity of the circuit until they become almost indispensable.

GEORGE B. HOADLEY (M '41)

(Professor of electrical engineering, North Carolina State College of Agriculture and Engineering of the University of North Carolina, Raleigh, N. C.)

European Engineering Practices

To the Editor:

Kindly allow me to make a few remarks on the article, "European Engineering Practices," by M. J. Delerno and F. V. G. Bird, published in the September issue (*pp 835–42*).

It is certainly most unfortunate that each European country has its own standards. It would be desirable that some international committee would take over the task to make uniform standards for all countries.

As far as sources of water power are concerned, I would like to draw the reader's attention to Austria. We have at least 25 billion kilowatt-hours per year available in our rivers, of which only one-fifth is harnessed. We have not only high-pressure plants for which Pelton turbines or Francis turbines are selected according to conditions on site, but low-pressure plants such as our schemes for the rivers Danube, Drau, Enns, and so forth. However, we have not sufficient electric energy during the winter months, because the installed capacity in our power stations is too small at present and for some years to come.

We found certain advantages in the ungrounded system for high-tension lines. It is, for example, possible to keep a line in operation for three hours with an earth fault in one phase provided that the earth compensation of the relating system is fairly correct; but it is difficult to design Petersen or other compensation coils for 220 kv and higher voltages. It is probably an advantage to build those lines with grounded transformer neutrals. But some of our European engineers have a prejudice against it.

It is a pity that electronic exciters are not yet known in Europe. They have distinct advantages over direct-connected exciters and should be introduced by European manufacturers.

It has been only a few months since our company began receiving *ELECTRICAL ENGINEERING* which I read with the greatest interest because it presents so much information and so many good ideas useful to the design engineer.

WOLFGANG HAHN

(Klagenfurt, Austria, Postfach 254)

A New Monetary Unit

To the Editor:

In these days of astronomical figures in our national finances, the references (which occupy so much daily space, in printed matter) to hundreds of billions of dollars, is increasingly cumbersome. It is thus increasingly desirable to adopt some such device as engineers have adopted when they have been faced with similar problems.

It may be appropriate at this time to suggest that consideration be given to a unit which might be called a "mega dollar," that is, a million dollars. A symbol could be devised analogous to our dollar sign, to designate such a unit, perhaps a conventionalized letter "M" superimposed upon a conventionalized letter "S" in monograph form.

This would have such obvious advantages that we, as members of the engineering profession, well might urge the idea upon the nation at large. Perhaps a new word would be coined, a "megabuck."

SIDNEY WITHINGTON (F '24)

(Chief electrical engineer, The New York, New Haven and Hartford Railroad Company, New Haven, Conn.)

Alternating Fluxes

To the Editor:

A number of articles and comments in regard to engineering education have appeared in recent issues of *ELECTRICAL ENGINEERING*. In the study of a-c machinery such as motors, generators, and transformers, it would seem that the subject of alternating fluxes is equally as important as the subject of alternating currents. While the subject of alternating currents is treated logically and in detail, the subject of alternating fluxes is almost wholly neglected in electrical engineering textbooks. This neglect together with the indiscriminate use of the ambiguous term "field," referring to either or both magnetomotive force and flux, imparts to the student a general conception that magnetomotive force and flux are identical and that an alternating flux is always in a fixed ratio to and in time phase with the magnetomotive force. For example, in explaining the development of a rotating flux by polyphase a-c excitation, textbooks make no distinction between magnetomotive force and flux although they make a definite distinction between electromotive force and current.

The similarity of Ohm's law governing the relation between constant electromotive force, current, and resistance, and the law governing the relations between constant magnetomotive force, flux, and reluctance is recognized generally. While with one exception the same similarity of relation also exists between alternating currents and alternating fluxes, this is not mentioned in textbooks. The one difference lies in the fact that with alternating currents the current in phase with the electromotive force is the energy component, while with alternating fluxes the flux in quadrature with the magnetomotive force is the energy component. Thus, while the energy developed in an a-c circuit is the product of electromotive force, current and the cosine of their time phase angle, the energy developed in an alternating magnetic current is the product of magnetomotive force, flux, and the sine of their time phase angle. This difference comes about since electromotive force is in quadrature with the flux, while the magnetomotive force is in phase with the current. Thus, when current and electromotive force are in phase, flux and magnetomotive force are in quadrature. By taking account of this relation and substituting sine for cosine to determine the energy, alternating flux problems can be solved by the same methods used with alternating current problems.

Another confusing situation is the fact that with alternating fluxes no terms are available for certain similar terms applying to alternating currents. For example, when an alternating flux threads a closed winding, inducing a current in the winding, the flux lags the magnetomotive force in the same way that an alternating current in a winding encircling a magnetic core and inducing a flux therein lags the electromotive force. The inductive action in the electric circuit that causes the alternating current to lag the electromotive force is termed inductance, while the similar inductive action in the magnetic circuit that causes the alternating flux to lag the magnetomotive force has been assigned no specific name and is generally entirely neglected in textbooks.

It appears that textbooks profitably could devote more attention to alternating fluxes. A better understanding of the subject would enable the student to develop a clearer conception of the actual physical actions where alternating fluxes are involved.

EDWARD BRETCH (M '19)

(Century Electric Company, St. Louis, Mo.)

Decimal Units for Time

To the Editor:

A suggestion about decimal units for time.

At the time of the introduction of the metric units, centimeter and gram, and of the international cm-g-sec-system, all based on decimals, one factor was overlooked: to select a decimal system also for the time. It is, of course, not possible to do away with

the year and the day, determined by our solar system, but the hour, the minute, the second, are arbitrary and they complicate all computations involving time by the unnecessary factors 24 and 60.

A decimal system, based on the day, could be devised as follows. One day has 100 units—call this new unit tempus, abbreviated "tem": 1 tem = 0.24 hour = 14.4 minutes. We need a still smaller unit. Call 1/1000 tem a moment, abbreviated "mom." One mom then would correspond to 0.866 second.

We would have decitems, centitems, millitems equal to moms. Also dekamoms, hectomoms, kilomoms equal to tems.

Of course, we would have to have new watches, and the watch industry would be happy. There would be no difficulty from this side.

But the trouble is that we would need new units for force and energy, as the dyne and the erg are based on the acceleration of 1 centimeter per square second. Of course, the kilowatt-hour would become obsolete too.

Thus I am resigned that this suggestion will be and remain sterile.

G. HULDSCHINER (M '41)

(640 Fort Washington Avenue, New York, N. Y.)

Electrical Problem Solutions

To the Editor:

The electrical problem presented by S. A. Ferguson and G. S. Thomas (*EE, Aug '48, pp 833–4*) can be resolved easily if the difference between the resultant and the equilibrant is noted when two vectors are added. Expressed in vector form, $E_{ab}+E_{bc}+E_{ca}=0$, from which algebraically, $E_{ab}+E_{bc}=-E_{ca}$, where E_{ca} is the equilibrant. Rewriting this equation and removing the minus sign from E_{ca} by reversing its phase 180 degrees, we obtain $E_{ab}+E_{bc}=E_{ac}$, where E_{ac} is the resultant, and is 180 degrees out of phase with E_{ca}.

In any circuit, the summation of the voltages measured in traversing a closed loop is always equal to zero. (A single point cannot support a difference in voltage.) Thus, by the foregoing equations it is obvious that whether phase 3 is physically represented by a coil or not, the voltages E_{ca} and E_{cx} are one and the same, as each is the equilibrant of E_{ab} plus E_{bc}.

The authors have introduced the apparent fallacy by adopting two different locations for voltage measurement in obtainin their voltages Ee^{j0} and Ee^{j180}. They could have obtained the voltage Ee^{j0} equally as well with all three transformers connected in closed delta by measuring the voltage E_{xc} instead of E_{cx}.

This problem emphasizes again the necessity for proper use of voltage notation conventions and extreme care in the use of resultants and equilibrants in vector addition.

W. B. BRIGHTY (M '48)

(Synchronous motor design engineer, General Electric Company, Fort Wayne, Ind.)

To the Editor:

The difficulty raised by S. A. Ferguson and G. S. Thomas in the August 1948 issue of Electrical Engineering arises from a confusion of signs.

Referring to the diagram, when we say that the delta-connected windings 1, 2, and 3 have 3-phase voltages induced in them, the positive sense of the voltages are *AB*, *BC*, and *CA*. It is on the basis of this convention that we say that the voltages are displaced 120 degrees and that $E_{ab}=Ee^{j60}$, $E_{bc}=Ee^{-j60}$ and E_{ca} (or E_{cx}) $=Ee^{j180}$.

Even if we omit winding 3 entirely, the voltages are the same if the same convention of signs is followed and the points, *A*, *B*, and *C* are taken in the same order. The voltages of the open delta system still will be E_{ab}, E_{bc}, E_{ca}; and not E_{ab}, E_{bc}, E_{ac}, as was stated in the letter. Since $E_{ca}=-E_{ac}=Ee^{j180}$, the voltages still will be displaced 120 degrees.

It might be helpful to look upon winding 3 as being connected across points *A* and *C* in parallel with the other two in series. The voltage between *A* and *C* therefore should be unaffected by the removal of winding 3 (under no load conditions and ignoring harmonics).

V. J. JOSEPH

(Care of Lloyd's Bank, Ltd., 67 Kingsway, London, England)

Flow Meter

To the Editor:

The following is my reply to the letter to the editor published in the August issue of *ELECTRICAL ENGINEERING* (*p 831*), in which George Keinath again comments on my article, "An Electric Flow Meter," which appeared in the December 1947 issue (*pp 1216–19*).

Regarding the novelty of the instrument and certain features of it which I described, I prefer to leave it to the Patent Office to decide the issue and I do so with great confidence in the ability and judgment of our patent examiners.

As far as the very interesting article is concerned which Professor Thomas published in *Iron Age* in 1911, it escaped my notice since at the time of its publication, I was only nine years old and not yet interested in flow meters.

Keinath remarks that the manufacture of the Thomas meter was discontinued many years ago. This is not surprising in view of serious shortcomings in its design, some of which I mentioned in my previous letter to the editor (*EE, May '48, p 511*). The basic principle of the Thomas meter, however, is very sound and certainly deserves serious consideration in the design of flow meters.

J. H. LAUB (M '36)

(Assistant to the president, Charles Engelhard, Inc., East Newark, N. J.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ALTERNATING-CURRENT CIRCUIT THEORY. By M. B. Reed. Harper and Brothers, New York, N. Y., 1948. 603 pages, illustrations, diagrams, charts, tables, 9½ by 6 inches, cloth, $5.50. Contains both fundamentals and applications. Experimental evidence for a theory is followed by a complete mathematical development. Particular attention is paid to the establishment of a working knowledge of reference directions and polarities of currents and voltages. There is an extensive list of problems at the end of each chapter.

AMERICAN ELECTRICIANS' HANDBOOK. By T. Croft, revised by C. C. Carr. Sixth edition. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, and London, England, 1948. 1,773 pages, illustrations, diagrams, charts, tables, 7½ by 5 inches, cloth, $6. This comprehensive handbook, designed to meet the needs of those with little electrical knowledge as well as the trained electrician and engineer, again has been revised and enlarged. New material on electron tubes and circuits, electronic devices in industry, control generators, control mechanisms, dry-type transformers, copper oxide and selenium rectifiers, signalite fuses, and many other devices has been included. All material is in accordance with the National Electric Code.

ATOMIC ENERGY. By Karl K. Darrow. John Wiley and Sons, Inc., New York, N. Y.; Chapman and Hall, Ltd., London, England, 1948. 80 pages, illustrations, diagrams, tables, 8½ by 5½ inches, cloth, $2. Contains four lectures given in the Norman Wait Harris lecture series at Northwestern University in 1947. The lectures include as much of the science of atomic energy as possible to give in four hours to an audience consisting largely of people whose special fields of interest were other than physics.

COLLEGE PHYSICS. By H. A. Perkins. Third edition. Prentice-Hall, Inc., New York, N. Y., 1948. 786 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $6.65; text edition, $5. The purpose is to give the student a substantial grasp of physical principles rather than to describe phenomena. Covering all the usual phases of physics included in an elementary text, this volume uses very simple algebra and trigonometry. Some historical background is given, and modern ideas are used throughout. Mention is made of such new developments as radar, and there is a considerable discussion of atomic energy.

ENGINEERING MATERIALS. By A. H. White. Second edition. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, London, England, 1948. 686 pages, illustrations, diagrams, charts, maps, tables, 9¼ by 6 inches, cloth, $6. The various aspects of engineering materials are presented, with enough theoretical explanation so that the engineering student may understand the materials he uses. The book has been revised throughout, and the material on wood, plywood and other laminates, and protective coatings, is almost all new.

FRACTURING OF METALS, a Seminar on the Fracturing of Metals held during the 29th National Metal Congress and Exposition, Chicago, Ill., October 18 to 24, 1947. American Society for Metals, Cleveland, Ohio, 1948. 311 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $5. Composed of papers dealing with an extremely complex problem, this volume does not claim to be a complete and correlated picture of the laws of fracture, but deals with the specific phases which concerned members of the seminar. Such varied topics as micromechanism of fracture, notched tensile testing and theory of static fatigue for brittle solids are considered in the 19 papers included.

HANDBOOK OF CHEMISTRY AND PHYSICS. Edited by C. D. Hodgman, 30th edition. Chemical Rubber Publishing Company, 2310 Superior Avenue, Cleveland 14, Ohio, 1948. 2,686 pages, tables, cloth, $6. The present issue retains the original purpose—to provide accurate data constantly wanted by physicists and chemists in convenient form for quick reference. The present edition has been revised throughout and new matter added where called for. In addition to the material relating strictly to chemistry and physics, there is considerable information in such fields as metallurgy, magnetism, electricity, radio and electronics, photography, statistics, geology, and mineralogy.

HEAT ENGINES. By S. H. Moorfield and H. H. Winstanley. Third edition. Edward Arnold and Co., London, England; Longmans, Green and Company, New York, N. Y., 197. 326 pages, illustrations, diagrams, charts, tables, 7½ by 5 inches, stiff cardboard, $2.25. Containing fundamental principles, this book is intended for use as a text for a year course in heat engines. The Fahrenheit temperature system is used in all steam calculations and data. Othe portions of the text have been rewritten and new examples included. A background of elementary physics is needed.

INTRODUCTION TO METALLIC CORROSION. By U. R. Evans. Edward Arnold and Co., London, England; Longmans, Green and Co., New York, N. Y., 1948. 211 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $3.25. An introductory text useful to both students and scientists. It is not a guide to practical preventive measures or a reference work, but rather a book suitable for continuous reading. It begins with an historical note which is followed by a basic chapter on electrochemistry. Only simple equations are used in all but the chapter on statistical methods.

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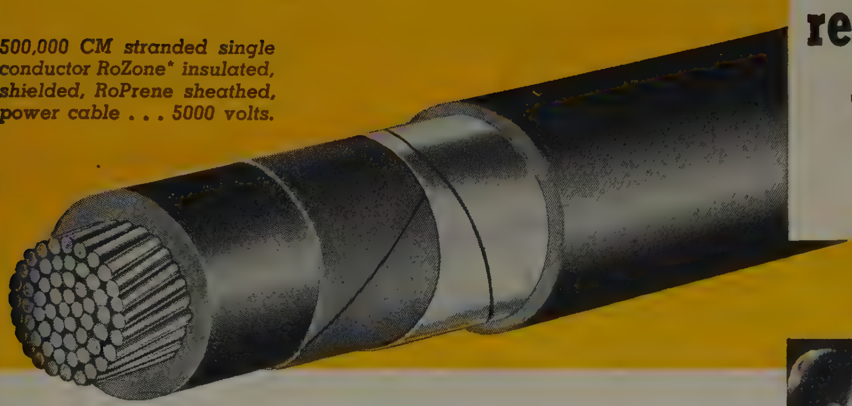

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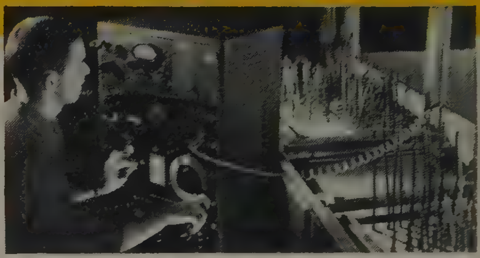

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ROME CABLE ROME, N.Y.

INDUSTRIAL NOTES ....

New G-E Welding Divisions' Manager. A. F. Vinson, formerly assistant production manager, General Electric Apparatus department and chairman of the G-E Welding Committee, has been appointed manager of the company's Welding Divisions. Mr. Vinson has been with the company since 1929.

Johns-Manville Opens New Tilton, N. H. Plant. October 7th saw the formal opening of the new Johns-Manville plant in Tilton, N. H., especially designed to manufacture new types of wholly inorganic electrical insulations in flexible asbestos sheets.

Sola Electric Appointment. H. U. Hjermstad has been appointed assistant to the president of the Sola Electric Company. Mr. Hjermstad was formerly with Federal Enterprises, Inc., in charge of manufacturing and engineering for the past eleven years.

Westinghouse Buys New Plant. Westinghouse Electric Corporation leased the Joshua Handy Iron Works 20 months ago under terms of a 10-year lease with the option to purchase by Nov. 1, 1948. The company has taken up this option. The plant produces distribution and power transformers, alternating-current motors, steam turbines up to 12,500 kilowatts generating capacity, voltage regulators, valves, large air moving equipment, gears, switchgear, and other products.

B. F. Bilsland Promoted. B. F. Bilsland has been promoted from manager of the Allis-Chalmers Chicago district to manager of the company's newly-formed Midwest region. Mr. Bilsland, a graduate of Purdue University, has been associated with Allis-Chalmers since 1919. Succeeding him as Chicago district manager is J. C. Collier, who has been with the company since 1916.

Nuclear Changes Name. To better describe the activities of the company, the former Instrument Development Laboratories, Inc., will in the future be known as the Nuclear Instrument & Chemical Corporation. This involves no change in personnel. The name change was decided upon with the expanding of the company's production of instruments for nuclear work. This has been occasioned by the ever-increasing penetration of the nuclear sciences into practical applications.

G.E. New Service Shop. Equipped with modern facilities for repairing all types of electric apparatus, the new General Electric apparatus service shop was opened October 29th in Medford, Mass., and will service on a round-the-clock basis all users in New England except Connecticut.

Ohio Brass Moves Boston Office. The new address of the Ohio Brass Company's Boston office is 80 Federal Street, telephone remains the same: Hancock 6-7153. Lindsay Ellms is the district manager in charge.

A. P. Massey Joins NBS Staff. The appointment of Andrew P. Massy to the staff of the Engineering Electronic Section of the National Bureau of Standards where he will head the electronic standardization group has been announced. Over the past 25 years, Mr. Massey has done extensive work on the theory and operation of electronics equipment, principally in the installation field.

L. J. Woods Vice-President Philco. Leslie J. Woods has been elected vice-president of Philco Corporation in charge of the Industrial division. Mr. Woods has been manager of this division ever since he returned from the war.

TRADE LITERATURE • • •

Tagliabue Instruments Catalogue. 3 pages. This catalogue illustrates and describes Tagliabue's complete line of Celectray potentiometer pyrometers. Send for your copy of Catalogue 1101pJ to C. J. Tagliabue Corporation, 614 Frelinghuysen Avenue, Newark 5, N. J.

Miniature Ball Bearings. The issue, double in size of the previous one, is devoted to specifications on the 40 or more types and sizes of standard miniature ball bearings, including radial, super-light, pivot, angular contact, and thrust bearings produced by the Miniature Precision Bearings, Inc. Information also is included on variations of standard bearings and the supplying of special bearings in their size range. Many of the miniature bearings are available in beryllium copper and stainless steel as well as chrome alloy bearing steel. Send your request for this catalogue to Miniature Precision Bearings, Inc., Keene, N. H.

Precision Investment Casting Bulletin. This process, as a means of cutting production costs when screw machine work, die-casting, or sand castings that can be easily machined prove impractical, is covered in a new Allis-Chalmers bulletin. Illustrated are 24 sample parts ranging from a stainless steel thermometer clamp for the dairy industry to bronze bearing blocks for a high-speed precision camera. The bulletin also supplies answers to numerous questions on precision casting, such as the type of materials that can be cast, the closeness to which tolerances can be held, the limit to the shapes and designs that can be cast. Copies of this bulletin, "Precision Investment Casting" 19B6451A, are available upon request from Allis-Chalmers Manufacturing Company, South 70th Street, Milwaukee, Wis.

(*Continued on page 52A*)

TRADE LITERATURE *(Continued from page 16A)*

Rural Manual. A new "Rural Manual," just announced by Locke Incorporated, contains characteristics and dimensions of all Locke pole line hardware, insulators, and associated materials used on Rural Electrification Administration projects. Copies of the new manual may be obtained by writing to the Merchandising Division, Locke Incorporated, Post Office Box 57, Baltimore 3, Md.

Conoidal Fans Catalogue. 68 pages, fully illustrated. Type "LL" Limit Load Conoidal Fans Bulletin 3675 of the Buffalo Forge Company, contains illustrations and descriptions of the various types of "LL" Limit Load Conoidal fans. The type "LL" Limit Load fan is absolutely non-overloading, regardless of the amount of air delivered. Features of the fans are removable bearing liner, extra large oil reservoir with accessible drain plug, large size quick filler plugs, and overflow fittings which indicate the oil level. Noise can be reduced to a minimum on these fans by the use of sleeve bearings, but for the higher speed industrial installation ball bearings are preferable. A copy of this catalogue may be had by writing to Buffalo Forge Company, Buffalo, N. Y. Specify Bulletin 3675.

AN Connectors and Fittings. Amphenol's Catalogue A-1 on AN connectors and fittings contains a wide assortment of Army-Navy electric connectors presented in a simplified manner. Each page gives specifications as to number of contacts, current or wire size, voltage, or contact spacing. Illustrations show the assortment of insert arrangements available, and the number and size contacts and mechanical spacing are tabulated. AN fittings are comprehensively indexed for easy selection. Send requests for Catalogue A-1 to American Phenolic Corporation, 1830 South 54th Avenue, Chicago 50, Ill.

Motoreducer Bulletins. The Falk Corporation announces that the new "Motoreducer Bulletins" will be available soon to provide complete information concerning the Falk all-steel Motoreducer. Advantages, features, selection tables, weights, dimensions, and the like will be listed in these bulletins. Write to The Falk Corporation, 3001 West Canal Street, Milwaukee 8, Wis., for your copies.

Simplex Catalogue. "Simplex Aerial Cables Catalogue," describes the Simplex-Anhydrex Neoprene-jacketed self-supporting aerial cable and lists its advantages. The spinner-type installation also is described in detail and insulation problem is discussed. Write to Simplex Wire and Cable Company, 79 Sidney Street, Cambridge 39, Mass., for a copy of this booklet.

Servit Selector. As a handy reference to simplify the choice of the correct type of Servit (split-bolt connector) for various conductor combination, the Burndy Engineering Company has published "Servit Selector"—Bulletin 48Q3. This Servit used for taps, dead ends, service entrance, motor lead, and junction box connections is supplied for copper, Copperweld, aluminum, A.C.S.R., Amerductor, Amersteel, steel and for combination of different conductor metals. Copies of Servit Selector are available upon request to the Burndy Engineering Company, 107 Bruckner Boulevard, New York 54, N. Y.

NEW PRODUCTS • • •

Tone Generator. High-quality audio oscillator and sensitive meter, that supply a suitable tone for use in equalizing remote telephone lines, are features of a new small, portable tone generator, known as type *WA-26A*. The new instrument, a product of RCA engineering products department, is designed primarily for use in broadcasting studios. The tone-generator circuit is an R-C type, allowing selection of ten frequencies from 50 to 15,000 cycles per second. The output is metered and calibrated in dbm. An output of either 150 ohms or 600 ohms may be selected by means of a switch mounted on the front panel. The equipment is supplied with a black leatherette carrying case, and the over-all weight with batteries in nine pounds, four ounces. Specific information on this new generator may be obtained from Radio Corporation of America, RCA Victor Division, Camden, N. J.

(Continued on page 54A)

Simplex-ANHYDREX Series Lighting Cables are designed without metallic armors for installation underground, with or without ducts. Construction is simple, consisting of alloy-coated copper conductors, solid or stranded to meet your requirements; ANHYDREX insulation, a moisture-resistant compound of high dielectric strength and long life; and a tough outer jacket of neoprene.

Simplex-ANHYDREX Series Lighting Cables may be buried in the ground without additional protection. Their ANHYDREX insulation is exceptionally stable in the presence of moisture and water. Their neoprene jacket resists ground acids and alkalies, abrasion, oil, and heat. Absence of metallic coverings eliminates such hazards as electrolysis, sheath currents, and crystallization. Where ducts are specified, the smooth outer jacket assures easy cable pulling.

Simplex-ANHYDREX Series Lighting Cables are available for street, airport, park, and industrial lighting circuits. They are part of the ANHYDREX Parkway group which also includes cables for underground service entrance, distribution networks, telephone, signal, and control systems. Write us direct or contact our representative in your area for detailed information.

Simplex

WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 SIDNEY ST., CAMBRIDGE 39, MASS.

NEW PRODUCTS (*Continued from page 52A*)

U. S. Electrical Varidrive Motors. 16-page bulletin. Describes in colorful form how a variable speed motor can be applied to countless operations, to reduce operator fatigue and appreciably increase production. A copy may be obtained from U. S. Electrical Motors, Inc., 200 East Slauson Avenue, Los Angeles 54, Calif.

Rolling Spring Switches. Incorporated in this catalogue are the latest specifications on coin switches, open-blade switches, midget switch, nut-type switch, as well as complete information on actuators. The booklet is fully illustrated to show various applications. A copy of this bulletin may be obtained from The Acro Electric Company, 1305 Superior Avenue, Cleveland 14, Ohio.

Air-Cooled and Water-Cooled Triodes. Amperex Electronic Corporation, 79 Washington Street, Brooklyn, N. Y., has announced the Amperex *492* and *492-R*, high-frequency water-cooled and air-cooled triode amplifier and oscillator tubes. The maximum rating of 5-kw plate dissipation applies up to a frequency of 150 megacycles. The *492-R* radiator is capable of dissipating full power with an air flow of 170 cubic feet per minute, the radiator design presenting optimum conditions for the ratings. The *492* anode is capable of dissipating 5 kw of power with a water flow of 3–5 gallons of water per minute. The water jacket is an integral part of the tube, and a separate adaptor is provided for connection to external water lines. For high-frequency coaxial circuits, the water jacket is adaptable for extension into standard 2-inch copper tubing of any desired length to permit adjustment for a particular frequency.

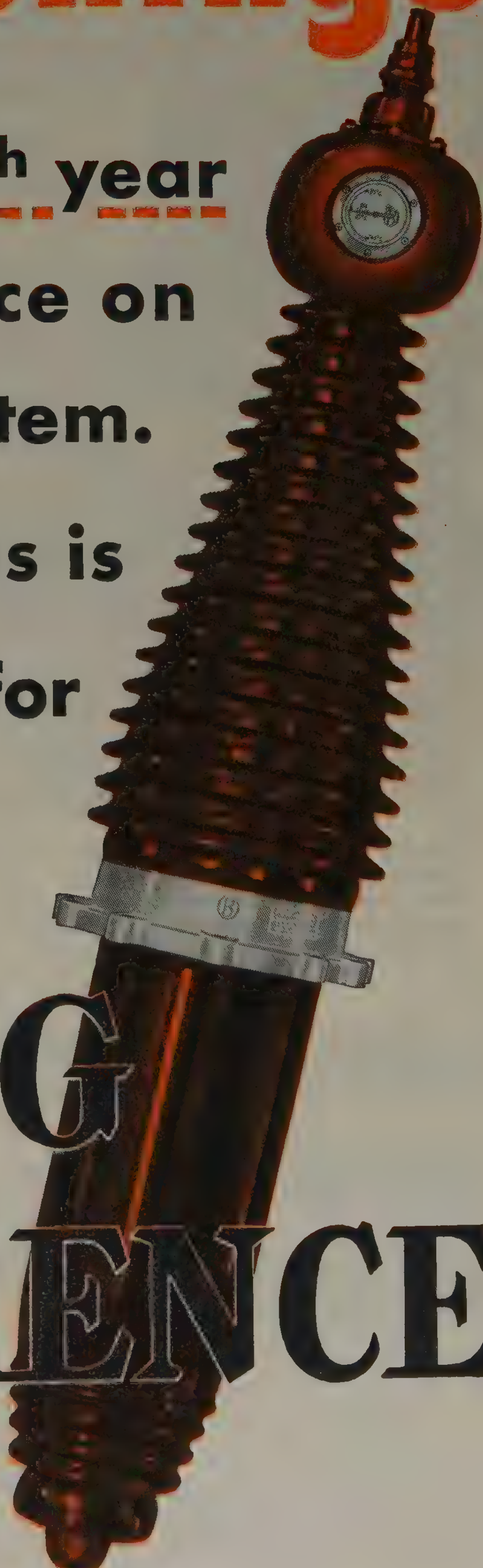
Contact-Making Thermometer. A new contact-making thermometer, combining the features of an indicating thermometer in addition to an alarm or control device, has been introduced by Weston Electrical Instrument Corporation. The instrument consists of an all-metal thermometer with an adjustable contact arm mounted in the glass and bezel. A screw-type terminal block mounted on the periphery of the case front provides for an easy electric connection. Contacts are of the magnetic type. The contact arm easily is set to make contact at any temperature over the entire scale, and while contact may be broken manually after an alarm has been sounded, the contacts break automatically on a temperature change of about five per cent. The thermometer can be supplied to make contact on either increasing or decreasing temperature. Literature is available from the Weston Company, 617 Frelinghuysen Avenue, Newark 5, N. J.

New Type Relay. The Clare type "*J*" d-c relay is available in plug-in type which increases the value of this small, lightweight relay for installation where quick removal and easy replacement are desirable. Supplied with standard octal base plug, the

(*Continued on page 58A*)

Filled Bushings

are now in their 26th year of continuous service on a large southern system. Performance like this is the soundest reason for making O-B your



BUSHING PREFERENCE

over-all length of relay and plug is $3^5/_8$ inches. Length of relay installed is $2^{15}/_{16}$ inches from the panel. The type "*J*" relay is a product of C. P. Clare and Company, 4719 West Sunnyside Avenue, Chicago 30, Ill.

Speed Reducer. The Winsmith patented helical gear differential speed reducer, introduced by Winfield H. Smith Corporation, Springville, Erie County, N. Y., retains the advantages of previous models, and in addition possesses the advantages of direct centered load distribution, more rigid and vibratingless mounting, larger area for heat radiation, and increased quietness of operation. These new design features permit increased overhung load capacities for still greater operating economy and efficiency. The gears of this differential helical gear reducer are made integral and combined in a planetary frame to form a complete unified planetary element, resulting in constantly maintained smoothness of operations and equalized load distribution through all three sets of planetary gears.

Ratios from 5 to 1 to as much as 50,000 to 1 can be provided with no increase in number of parts. Horsepower ranges from 0.62 to 81.5. Six sizes are available for every phase of industrial service and are made in horizontal, vertical, and flange-mounted styles. More information may be obtained by writing the company for Bulletin *31H*.


FOR A BETTER SOLUTION TO THESE 3 DESIGN PROBLEMS
1 FOR FORCED DRAFT
2 FOR HOT OR COLD AIR CIRCULATION
3 FOR EXHAUSTING DUST OR FUMES
Specify....
FASCO SHADED POLE BLOWERS
FASCO Motor Blowers are especially adaptable for heating and ventilating devices and for cooling electronic equipment. More and more designers are standardizing on these 15 to 140 C.F.M. units for distributing air in confined spaces.
FASCO Shaded Pole Blowers offer advantages proved by years of engineering experience . . . quiet, economical, trouble-free operation, and long life.
FASCO ENGINEERS ARE ALWAYS READY TO HELP WITH YOUR BLOWER PROBLEMS. SEND FOR CATALOG AND INFORMATION.
WRITE
FASCO
MOTORS
A PRODUCT OF FASCO
F. A. SMITH MANUFACTURING CO., INC. • 450 DAVIS ST., ROCHESTER, N. Y.
FORMERLY Pilot MOTORS and BLOWERS

NEW all-metal WESTON

MAGNETIC CONTACT *easily set to make contact at any point on scale*

This new Weston combines the features of an indicating device with the advantages of an alarm or control instrument. A contact arm, mounted as shown above, is easily set to make contact at any temperature on the scale.

A terminal block on the periphery of the case makes electrical connection easy. The thermometer is all-metal, typically WESTON in ruggedness and reliability, with accuracy of ±1% as an indicating thermometer, and ±1½% as a contact making device. It is supplied in two types—for operation on either increasing or decreasing temperatures.

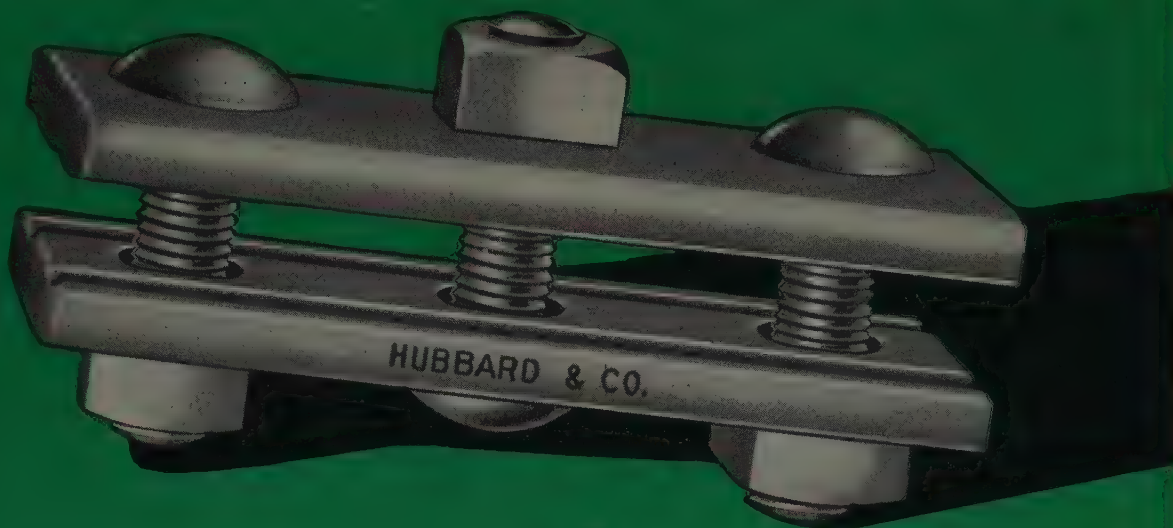
For complete information see your local WESTON representative or write Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey.

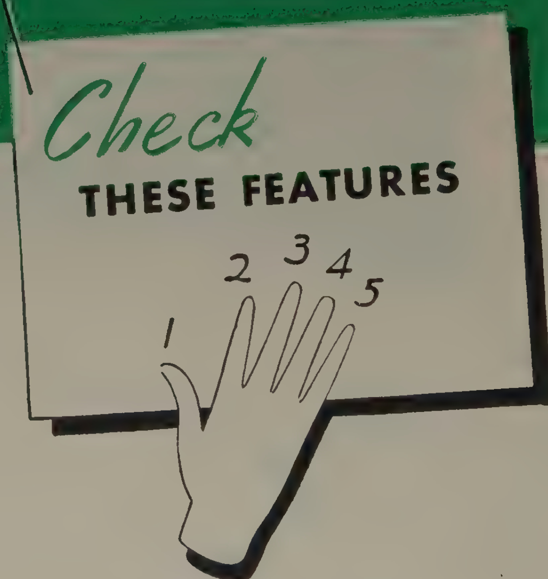
WESTON *Thermometers*

Industrial Thermometers | MAX-MIN Thermometers | Contact-making Thermometers

Albany • Atlanta • Boston • Buffalo • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Jacksonville • Knoxville • Little Rock • Los Angeles • Meriden • Minneapolis • Newark New Orleans • New York • Philadelphia • Phoenix • Pittsburgh • Rochester • San Francisco • Seattle • St. Louis • Syracuse • Tulsa • In Canada, Northern Electric Co., Ltd., Powerlite Devices, Ltd.

HUBBARD GUY CLAMPS





1. The *straight groove* eliminates the possibility of drawing a nut tight against an "arched" section which is out of contact with the strand. Hubbard Clamps have full clamping area. Hold to breaking strength of most strands.

2. The *straight groove* fits any and all twists, right or left hand and a variation in diameter without *creating* any high spots to *lessen clamping area.*

3. Bell-end grooves prevent injury to the strand caused by the sharp corners at the ends of the grooves of some clamps.

4. High carbon bolts prevent stripping or elongation. Heads are locked against turning while tightening—and the whole clamp is protected against corrosion by the best process commercially used—HUBBARD DOUBLE-DIP HOT GALVANIZING.

5. The range of strand sizes accommodated by No. 7461 Guy Clamp, without sacrifice of holding strength in any size, can not be matched by any other style of clamp. Exhaustive tests have been made on specially designed clamp sections, patented shapes and various snubbing ideas, all of which have failed to measure up to the HUBBARD straight, smooth groove type of clamp.

HUBBARD AND COMPANY

PITTSBURGH
CHICAGO

OAKLAND, CALIF.

PLANE SNIPS POWER LINE; CONTROLLER RE-ROUTES LOAD

L&N Load-Frequency Equipment Installed for Every-Day Service, Takes Emergency in Stride

This plane crash provided an unexpected test for L&N equipment . . .

. . . in the Load Dispatcher's Office, Glenwood, N. Y., which handled the emergency efficiently . . .

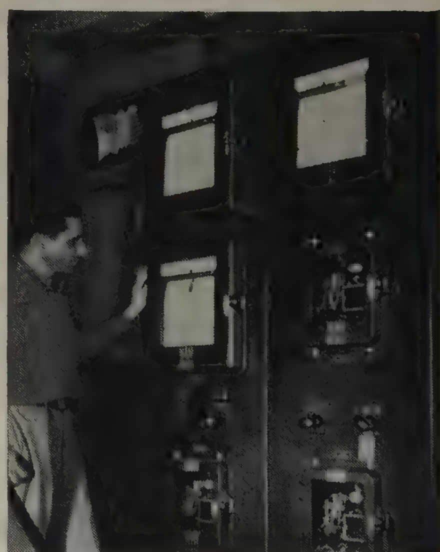
When Long Island Lighting Co. installed L&N Load-Frequency Control equipment, they were seeking principally to simplify the every-minute job of supplying power from the most efficient source.

The Control met their needs completely. It quietly directed traffic both within the Long Island system and along a tie to Consolidated Edison. It saved time, trouble, and money.

But before long a different kind of test confronted the equipment. An airplane, crashing into high voltage lines, chopped off 60,000 kw of the Glenwood Station's 145,000 kw load.

Instantly the excess output flowed along the tie. But in another instant, the Load-Frequency Controller jumped into action. It reduced the generation in quick steps. Correspondingly it cut back on the tie load. In a matter of minutes, the Station was generating only its own requirements. And power service on the station side of the break had not even trembled.

Why not investigate the possibilities of L&N Automatic Control for routine or emergency operation in your power plant?



. . . with control centralized as shown: left panel, top to bottom, Micromax Frequency Controller, Tie Line Load Controller, Master Load-Frequency Controller. Right panel, Micromax Reactive Load Recorder for Tie Line interchange, two Proportional Load Controllers.

LEEDS & NORTHRUP COMPANY, 4962 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl. Ad N-56-461(1)

Long life... Low cost per year

THE Kerite story—boiled down—is just that: "Long life . . . low cost per year." Cost-conscious cable buyers love it. Kerite has been proving it, too, for more than 90 years.

Kerite makes insulated wire and cable for all types of service—from low-voltage signal circuits to power circuits and high-voltage x-ray and other electronic applications . . . and for underground, overhead, and submarine installations.

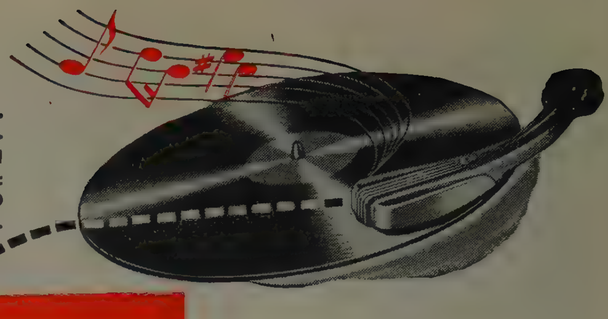
Our long experience provides the answer for most any cable problem. If you have a *new* problem requiring a special solution, our engineers will be glad to work with you so that you can take full advantage of Kerite insulation.

Kerite made to the old formula is still used in our insulation. That is what makes Kerite cable such a good buy today . . . and why it gives such long service at low cost per year. The Kerite Company, 30 Church Street, New York 7, N. Y.

Kerite Insulation—Your Cable's Best Life Insurance

DAYS KERITE

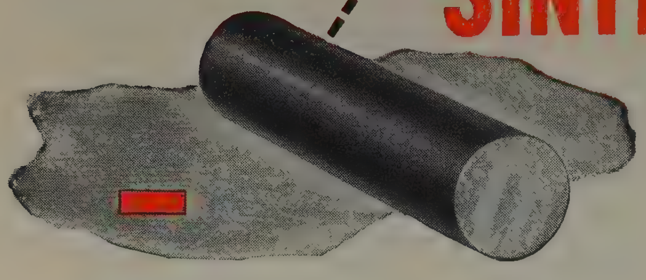
KERITE CABLE



The G-E Electronic Reproducer, which magnetically re-creates the full recorded sound, derives its magnetic field from a G-E SINTERED ALNICO 5 permanent magnet.

Announcing... A NEW G-E DEVELOPMENT

SINTERED ALNICO 5



Actual size of G-E SINTERED ALNICO 5 permanent magnet used in the G-E Electronic Reproducer is shown in red.

NEW ENGINEERING DEVELOPMENT

SINTERED ALNICO 5, General Electric's newest magnetic material, now enables you to design intricate shapes with higher external energy than ever before. The minimum guaranteed available energy is 3,500,000 gauss oersteds for most sizes and shapes. New G-E SINTERED ALNICO 5 possesses tensile properties several times those of CAST ALNICO 5 and can be produced economically in small size parts. You get better surface finish plus closer dimensional tolerances with new G-E SINTERED ALNICO 5.

NEW DESIGNS POSSIBLE

New SINTERED ALNICO 5 has higher external energy than either SINTERED ALNICO 2 or 4. This makes possible new designs heretofore impossible or impractical. It is especially adaptable where small powerful magnets having high magnetic properties are required. Because of their great stability and external energy, SINTERED ALNICO 5 magnets can save valuable space in your product. You can usually improve your product by re-designing to use high energy G-E SINTERED ALNICO 5. Typical applications now in production which use G-E SINTERED ALNICO 5 include the following: meters, relays, fountain pens, electronic reproducers, and compasses.

ENGINEERING SERVICE

G-E application and development engineers, working closely together, are ready to advise you on new SINTERED ALNICO 5 and other G-E magnetic materials. Our engineers are backed by years of research and the development of thousands of magnetic applications. They will be glad to work with you on your product design. For more information, please mail the coupon shown below.

YOU GET 5 ADVANTAGES

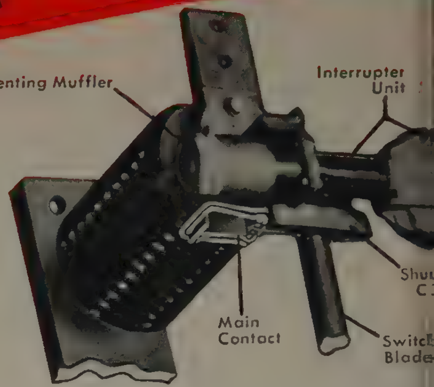
1. Higher external energy than either SINTERED ALNICO 2 or 4.
2. Tensile properties are several times greater than CAST ALNICO.
3. Excellent surface finish.
4. Close dimensional tolerances.
5. Intricate shapes possible.

METALLURGY DIVISION
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.
Please send me:
( ) Technical Report on new SINTERED ALNICO 5.
( ) Bulletin, CL-12, "G-E Permanent Magnets."
NAME.................... TITLE....................
COMPANY....................
PRODUCTS MFRD....................
ADDRESS....................
CITY.................... STATE....................

PERMANENT MAGNETS

GENERAL ELECTRIC

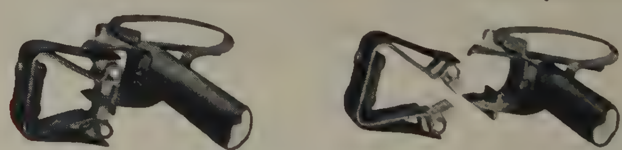
CD48-V3



View of one of the two interrupter units employed on each pole of 23- and 34.5-kv Interrupter Switches. In the opening operation, initial movement of the switch blade shunts the current through the interrupter units, thereby permitting the main contacts to open without arcing. Thr current is then interrupted within the interrupter units by a continuatio of movement of the switch blade, tripping levers on both interrupter unit simultaneously and causing separation at snap speed of interior termi nals located within an interior structure that provides condition favorable to arc interruption. The blade thereupon continues its swin to the full open position. Circuit interruption is thus accomplished wit

NO EXTERNAL ARC

the principal feature distinguishing S & C Alduti Interrupter Switche



Closed and open views of one of the main contact used on 23- and 34.5-kv Alduti Interrupter Switches. Hig pressure "line" contact engagement between slivered conta surfaces is established with a rocking, wiping, toggle actio which insures a clean, corrosion-resistant connectio and which disengages with a rolling, thrusting-out actio

TYPICAL APPLICATIONS

where 7.5- and 15-kv Alduti Interrupter Switches are already rendering meritorious service

Switching of both load and magnetizing currents on the primary of transformer banks

Switching of charging currents of large capacitor banks up to 2000 kvar on 2400-volt circuits and 3000 kvar on 4160- to 13,800-volt circuits

Breaking charging currents on overhead and underground feeders

Sectionalizing loaded distribution circuits

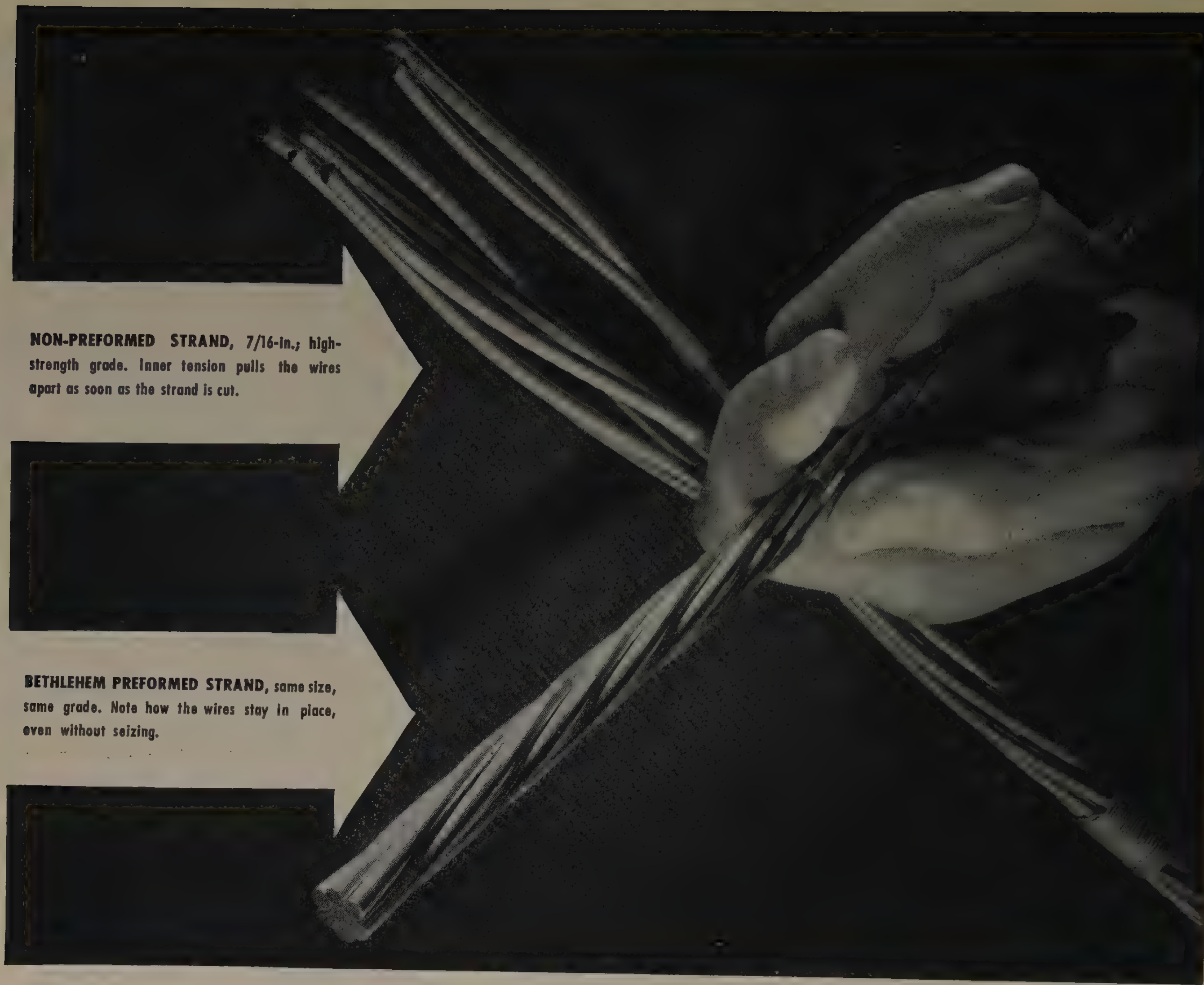
Switching plant feeders

Interrupting exciter current on feeder regulators

Throw-over from preferred to emergency circuits

And, when combined with S & C Power Fuses, short circuit protection is also provided.

S&C ELECTRIC



NON-PREFORMED STRAND, 7/16-in.; high-strength grade. Inner tension pulls the wires apart as soon as the strand is cut.

BETHLEHEM PREFORMED STRAND, same size, same grade. Note how the wires stay in place, even without seizing.

Bethlehem *PREFORMED* Strand
...so easy to handle...so low in cost

Ever consider the very real advantages of preformed strand? As made by Bethlehem, it can mean real savings in your handling costs—and you should see how linemen take to it. Here's why:

During the course of manufacture, each wire is preformed individually to its final helical shape. This operation does away with inner tension. Thus, when the wires are laid together as strand, it's almost impossible for them to spring apart—even when seizing is omitted.

Putting it another way, you could say that the wires have been tamed. When the strand is cut, the ends can't fly open. This makes preformed strand much easier to insert in fittings. It also reduces the chances of scratching or gouging the lineman's hands.

How about costs? You'll be surprised at how *little* extra you pay for Bethlehem preformed strand. It's a trifling item—and soon made up, for the lineman' work goes faster, better.

All sizes, types, and grades of Bethlehem strand can be preformed. And, of course, they all have the rust-resisting bethanized coating—made in three weights for corrosive conditions in any given area. Say the word and one of our representatives will be glad to give you the full story.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributors: Bethlehem Steel Export Corporation

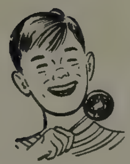
★ BETHLEHEM STEEL ★


before you buy . . .
stop!
see what LOCKE'S got . . .
Look to Locke for the new ideas

a sure way to-

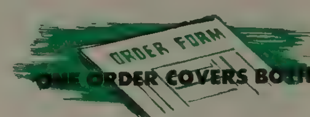
save time and headaches *on purchases of*

pole line hardware and insulators

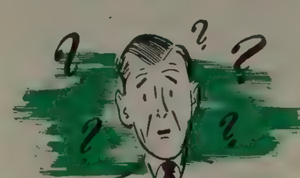


Like kids and candy, insulators and pole line hardware go together. Need one . . . and you need the other. It pays to specify Locke for both . . . because only Locke makes and distributes both. Here's how this combined operation on two such closely related products can save you time and headaches.

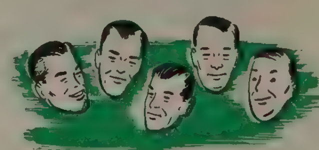
YOUR ORDERING PROCEDURE SIMPLIFIED– You save time and expense involved in order placement, bookkeeping and expediting . . . because when you specify Locke Products, one order covers everything.



YOU ALWAYS KNOW WHERE YOU STAND– When you do business with Locke, you're never "up in the air" wondering "who's doing what" with your order. That's because you place with us full responsibility for all materials going into a line. We, in turn, keep you posted on the status of your order, and do everything possible to expedite delivery.



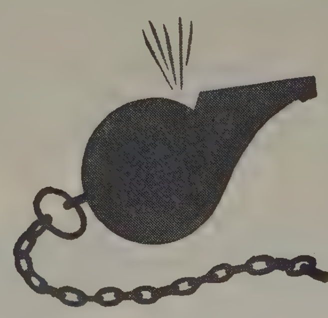
YOU GET GOOD, FAST SERVICE– We serve you through the largest distributor organization of its kind in the country. Locke distributors are practically everywhere. Warehouse stocks are readily available. Through our distributors we're able to give you fast, efficient, complete service—wherever you are, whenever you need it.



BETTER ENGINEERED PRODUCTS– Locke insulators and hardware are designed together to work together, and are made together—all in the same factory. Identical standards of *scientific* quality control, including modern inspection methods and statistical analysis, are applied to each—final assurance of uniform quality in all Locke products.

Keep these advantages in mind till next time you need insulators and hardware . . . then *save* yourself *time* and *headaches* by calling your Locke distributor first!

...before you buy...stop!
see what Locke's got



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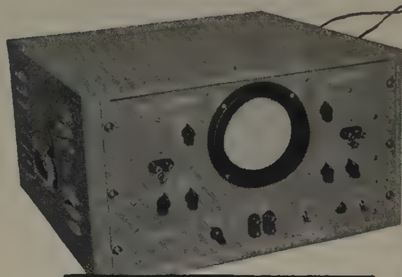
And here's the Du Mont selection of high-voltage oscillographs:



WRITING RATES TO ABOVE 400 IN./MSEC.

Type 281-A: **Devoid of internal deflection amplifiers, there are no frequency response limitations within the ratings of its Type 5RP-A tube. Phenomena have been recorded photographically at writing speeds of 85 inches per microsecond. With external power supply (such as Du Mont Type 286-A), photographic writing speeds of over 400 inches per microsecond may be examined. Recommended when oscillographic needs are extremely specialized or too advanced for standard commercial equipment. An accelerating potential as high as 29,000 volts is available with the Types 281-A and 286-A in combination.**

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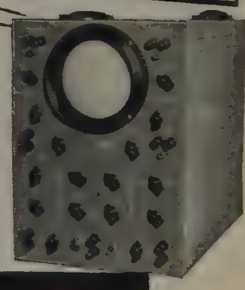
Type 250-H: **Covers range from d-c to 200 kc. Potentials containing both d-c and a-c components may be examined. Many special features for general usage include: linear time-base of unusual flexibility; automatic beam control on driven sweeps; internal calibrator of signal amplitude. This is a high-voltage oscillograph with maximum accelerating potential of 13,000 volts. Recordable writing rate of approximately 40 inches per microsecond.**



D-C to 200 KC

20 CPS-5 MC

Type 248-A: **Frequency range of 20 cps to 5 mc. Specifically intended for investigation of pulses containing high-frequency components of recurrent or transient nature. For this purpose it provides these necessary characteristics: High-frequency recurrent sweeps; short-duration driven sweeps; timing markers; signal delay network. Accelerating potentials up to 14,000 volts at recordable writing rate of approximately 69 inches per microsecond.**

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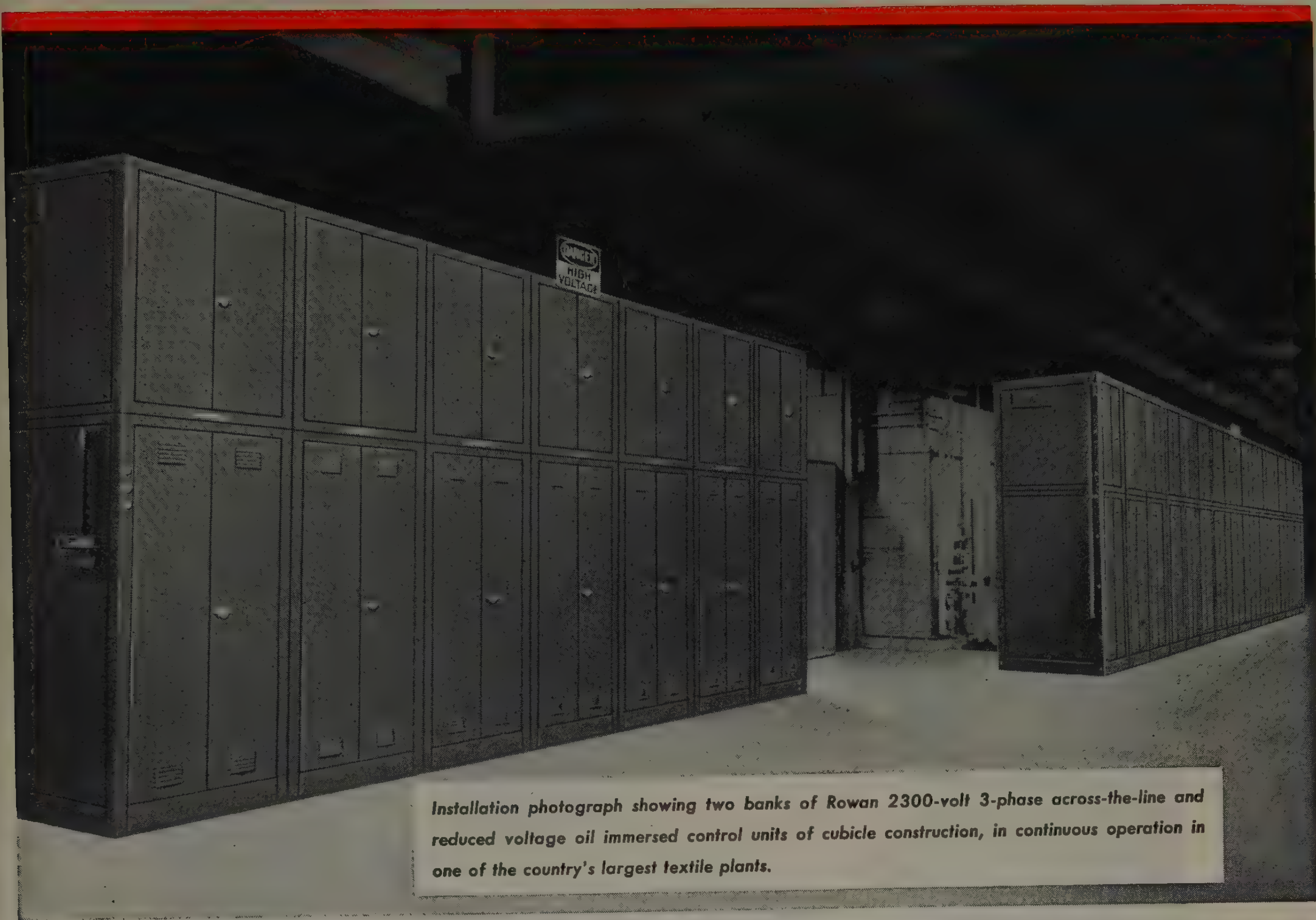

Installation photograph showing two banks of Rowan 2300-volt 3-phase across-the-line and reduced voltage oil immersed control units of cubicle construction, in continuous operation in one of the country's largest textile plants.

These across-the-line and reduced voltage starters are furnished as complete units, arranged for single or group mounting. Incorporated in each one: a self-contained, insulated bus; a self-contained control potential transformer; current-limiting or high interrupting capacity fuses; a specially designed, quick-acting, heavy-duty contactor: seal-off motor lead compartment; magnetic overload relays with electric reset, instantaneous and inverse time element; centralized, low voltage control compartment, and a self-contained, tank lowering device.

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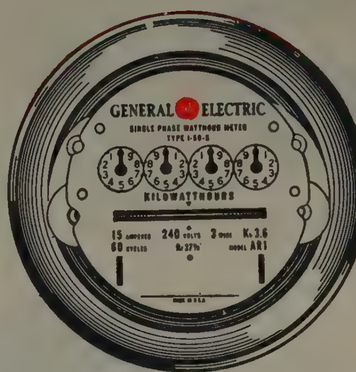

For greater insulation strength, reliability and secure positioning, the potential coil is molded to the electromagnet core with Du Pont polythene. This plastic combines high dielectric strength with low moisture-absorption.

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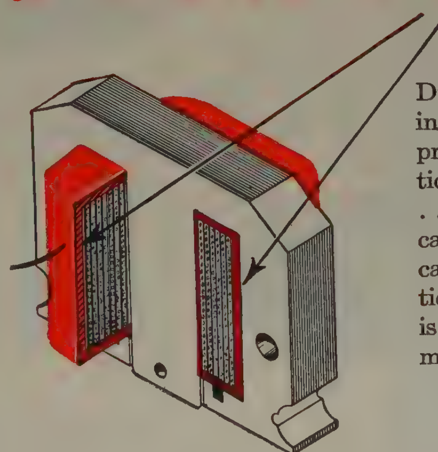

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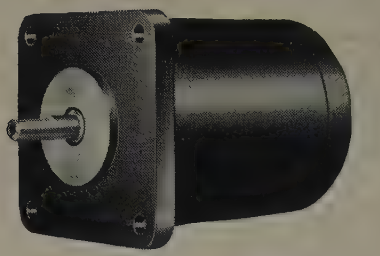
Kollsman offers additional AC units for remote indication or control applications



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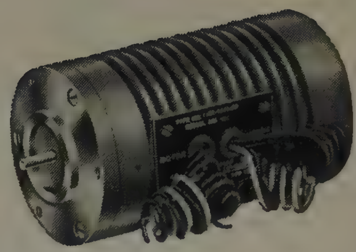
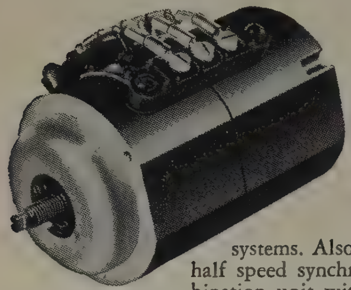


MOTOR DRIVEN INDUCTION GENERATORS — combination of a 2-phase, high-torque, low-inertia induction motor and an induction generator. Used as a fast reversing servo motor. Available with maximum stall torques of 1.0 (unit shown) to 6.7 (other units) oz/in.



SYNCHRONOUS DIFFERENTIAL UNITS—electromechanical error detector with mechanical output for use in position or speed control servo systems. Also a torque-producing half speed synchroscope. Small combination unit with two variable frequency synchronous motors and differential gearing. Output: Speed $= \frac{N_1 - N_2}{2}$; torque up to 1.0 oz/in.

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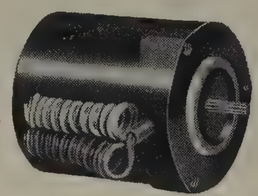

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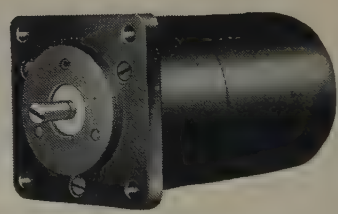

Because of their high responsiveness and precision, Kollsman Special Purpose Motors are particularly suited to systems requiring extremely accurate remote indication or positive electronic control. The units shown above are only representative of a complete line which includes many similar units in various voltages and frequencies. Among them, the instrumentation or control engineer will find, in many instances, the device that fills his specifications exactly.

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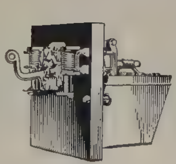

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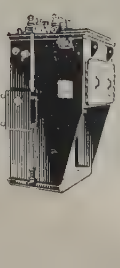

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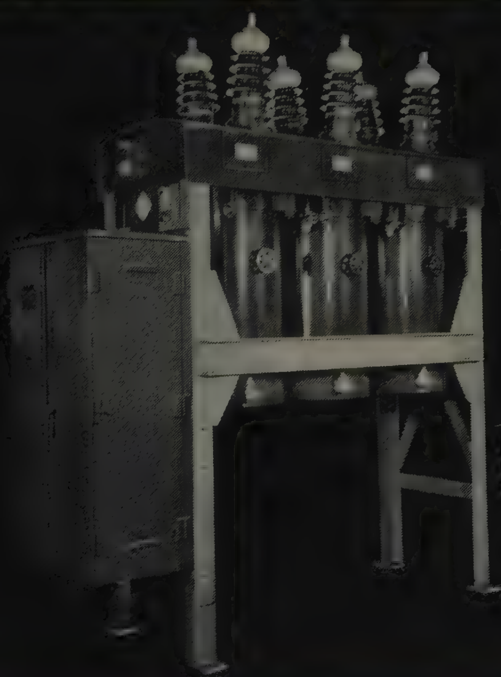

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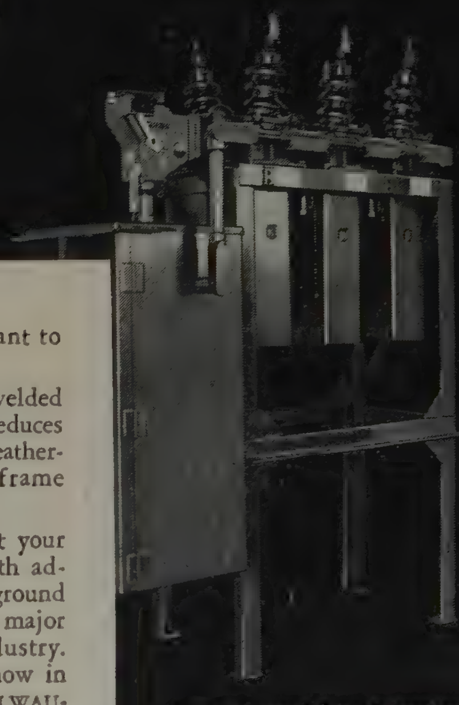

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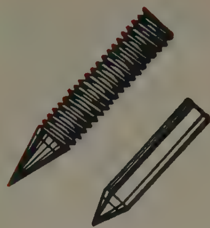

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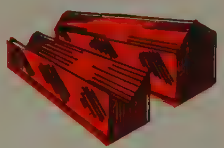

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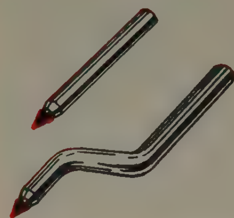

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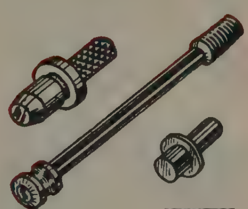

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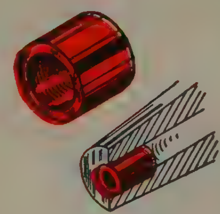

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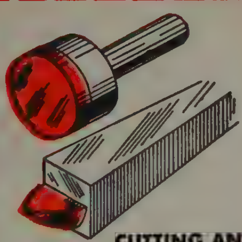

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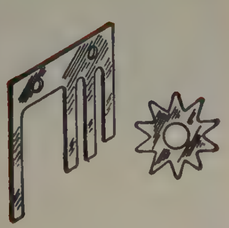

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LOW LOSS HIGH FREQUENCY INSULATION TO MEET HIGH MECHANICAL AND ELECTRICAL SPECIFICATIONS WITH OR WITHOUT METAL INSERTS

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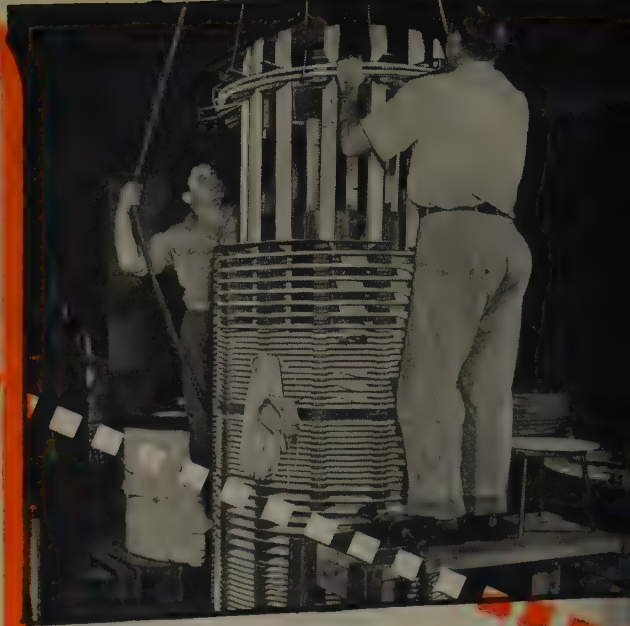
62 CLIFTON BOULEVARD
CLIFTON, N. J.

Assembling Core and Coils

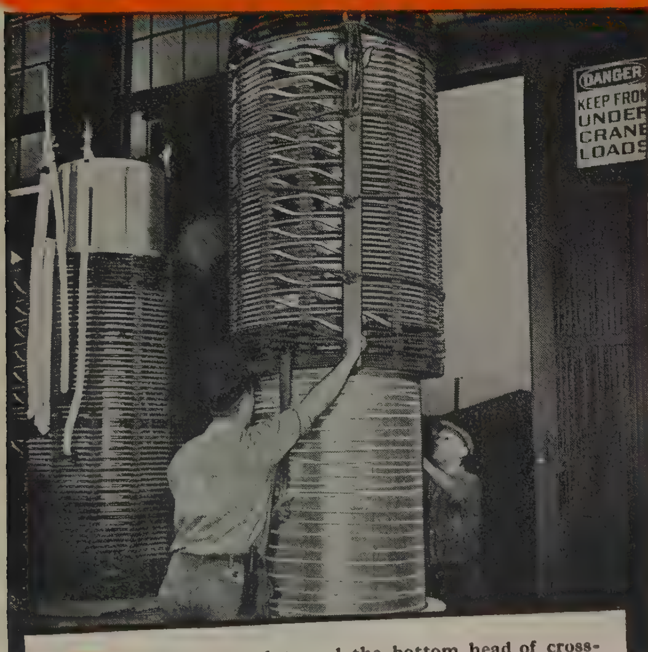
ANOTHER IMPORTANT PHASE IN THE MANUFACTURE OF

No other phase in the actual fabrication of a transformer is more important than the work of assembling the coils into complete windings, and installing them on the cores. Carelessness on the part of the workmen, or inexperience, may result in costly damage to the winding insulation. Consequently, only the most reliable and experienced men are used for this type of work.

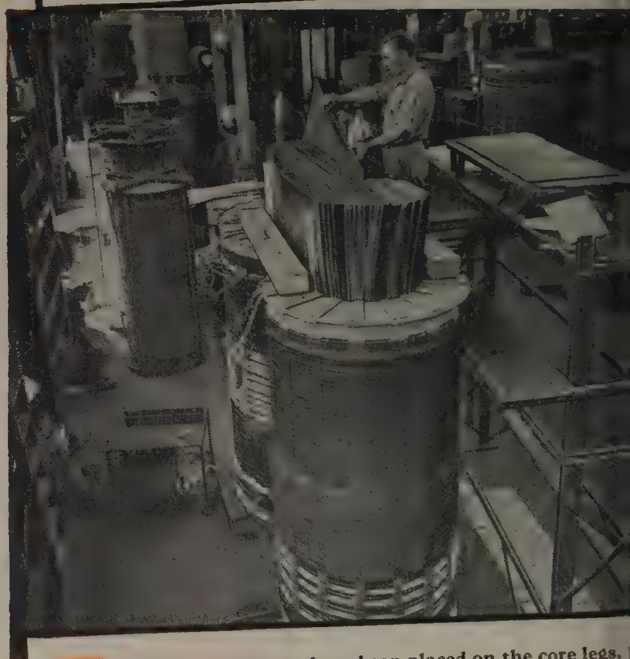
The care which Moloney exercises in connection with every detail of design and manufacture is your assurance of obtaining transformers that will provide real *on-the-job* performance.



1 Windings consisting of individual disc coils, are assembled on forms as shown above. Pressboard spacers separate the coils and form radial oil ducts which permit free flow of oil for uniform cooling. Extra spacers are used to spread portions opposite tap sections in the other windings to reduce cross-flux and provide more uniform impedance on the various tap connections.



4 After the core legs and the bottom head of cross-irons have been assembled, the windings are placed into position. Usually the lowest voltage winding is placed next to the core. The above photo shows the intermediate voltage winding of a three-winding transformer being placed over the low voltage winding. The latter had previously been covered with an insulating cylinder.



5 After the windings have been placed on the core legs, the top head of cross-irons is installed. Next, the top core clamping structure and the steel end plates are bolted into place. This makes a mechanically strong unit of the core-and-coil assembly. Note in photo that radial spacers are provided at top and bottom of coil stacks to permit flow of oil to the vertical oil ducts between the core and the low voltage winding.

MOLONEY

POWER AND DISTRIBUTION TRANSFORMERS EXCLUSIVELY SINCE 189

Pressboard spacers separate the individual disc coils and are fastened to the spacer bars which provide the vertical oil ducts between windings. This permits accurate alignment, providing mechanical strength to withstand the forces encountered under short circuit conditions. Connections between coils are gun-brazed as shown in the photo, and then thoroughly insulated.

3 Following assembly of the stack of disc coils into a continuous winding, it is compressed to the proper vertical dimension, securely clamped, then subjected to a series of drying, varnish impregnating and baking operations. These serve to (1) remove moisture from the insulating materials, (2) seal the windings against moisture, (3) provide mechanical strength for ease of handling when installing the winding on the core.

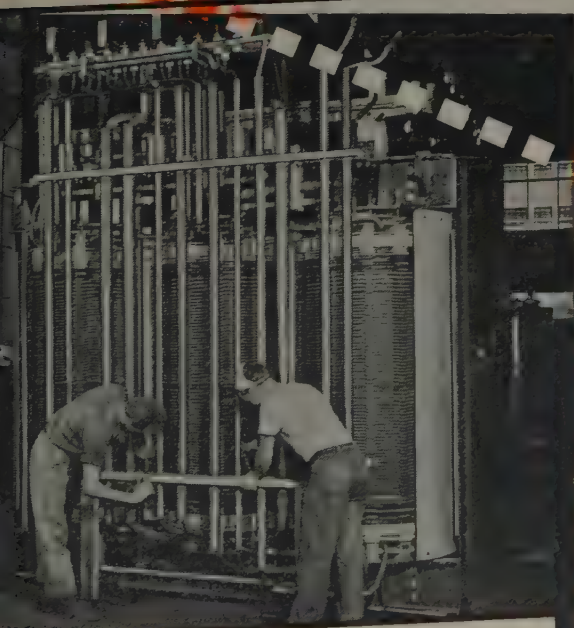


Photo shows completed core-and-coil assembly for a small three-phase power transformer, ready for preliminary testing. Leads are anchored firmly by means of insulating tubing. Lead connections have been carefully brazed and insulated. Insulating shields have been placed between phases and between the end plates and the windings.

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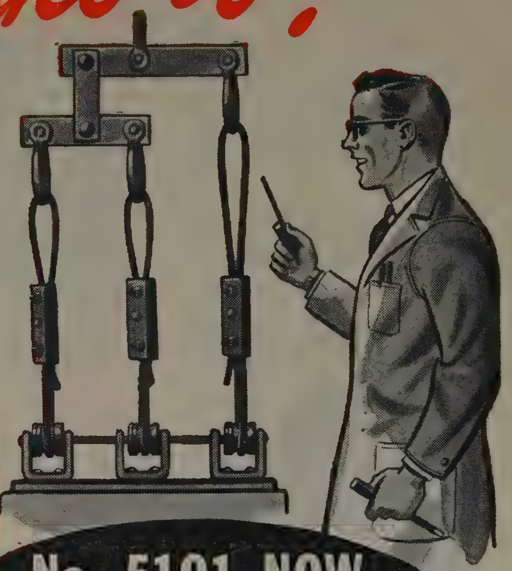

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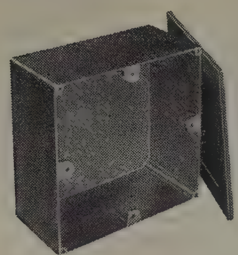
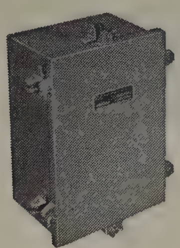
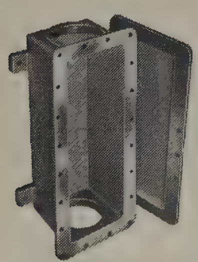


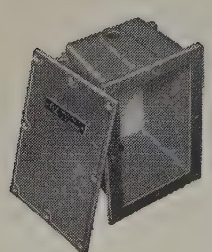
TYPE Y1200
Unflanged junction box with cover. Flush or Surface mounting.



TYPE Y3200
Weatherproof pull box. Complete with one-piece rubber gasket and hinged cover surface mounting.



TYPE Y6000
Explosive resisting junction box designed in accordance with Underwriter's Laboratory requirements. Cover and flange are accurately machined and correct bolt spacing provided. Flush or Surface mounting.



TYPE Y8000
Flanged watertight box with cover complete with rubber gasket. Flush or Surface mounting.

5214

When you specify O. Z. Cast Iron Boxes for industrial, railroad, airport, oil refinery and other heavy-load circuits, you specify the best. Cast from close-grained, grey iron, these sturdily constructed boxes are accurately machined to your requirements and then hot-dip galvanized to provide maximum corrosion resistance.

No matter what the operating condition . . . explosion resisting, watertight or weatherproof . . . you'll find a box to fit the job in O. Z.'s complete line. All boxes can be supplied with or without bosses or mounting lugs and are drilled for conduit entrances as required.

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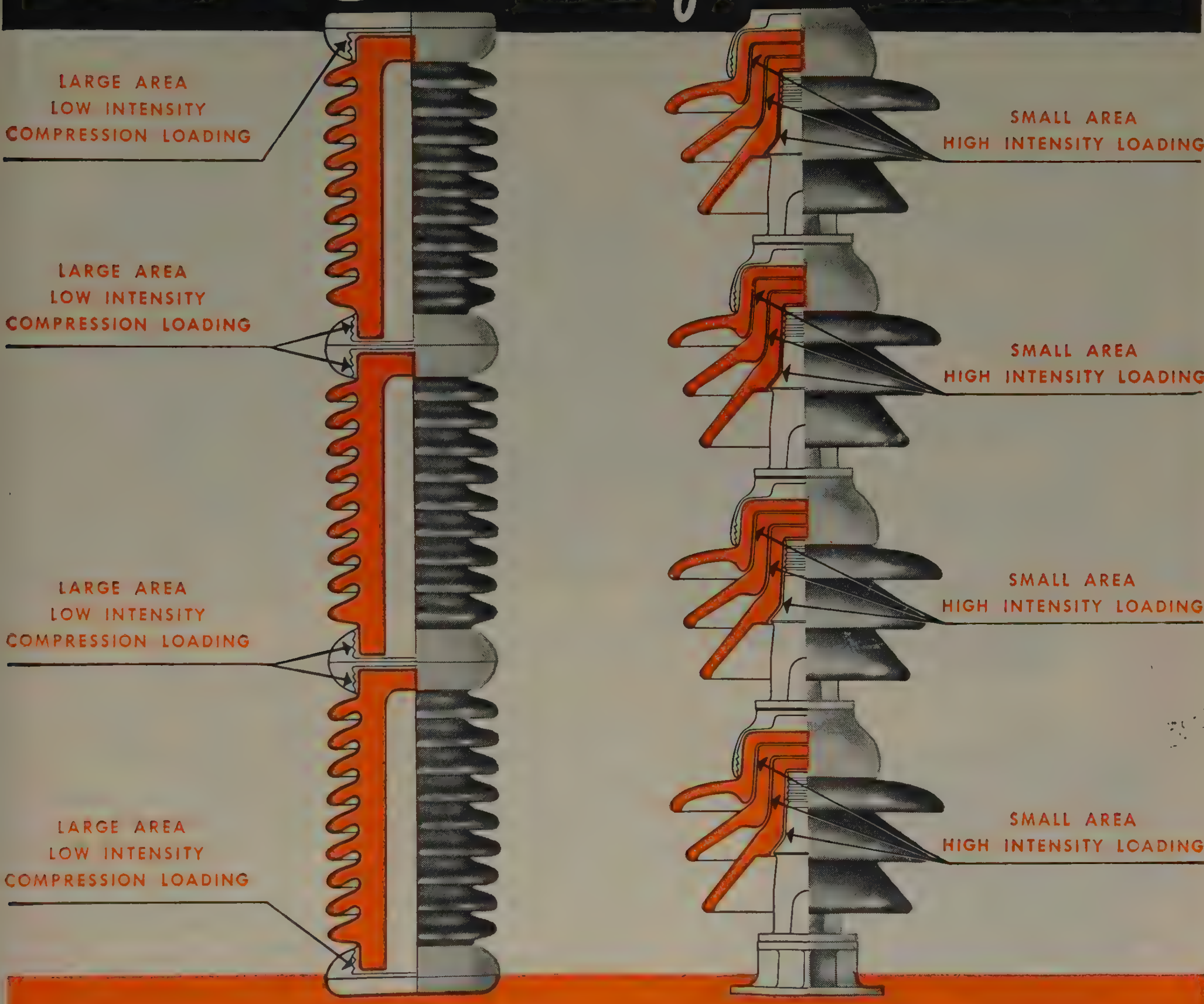
✓✓ Compare!

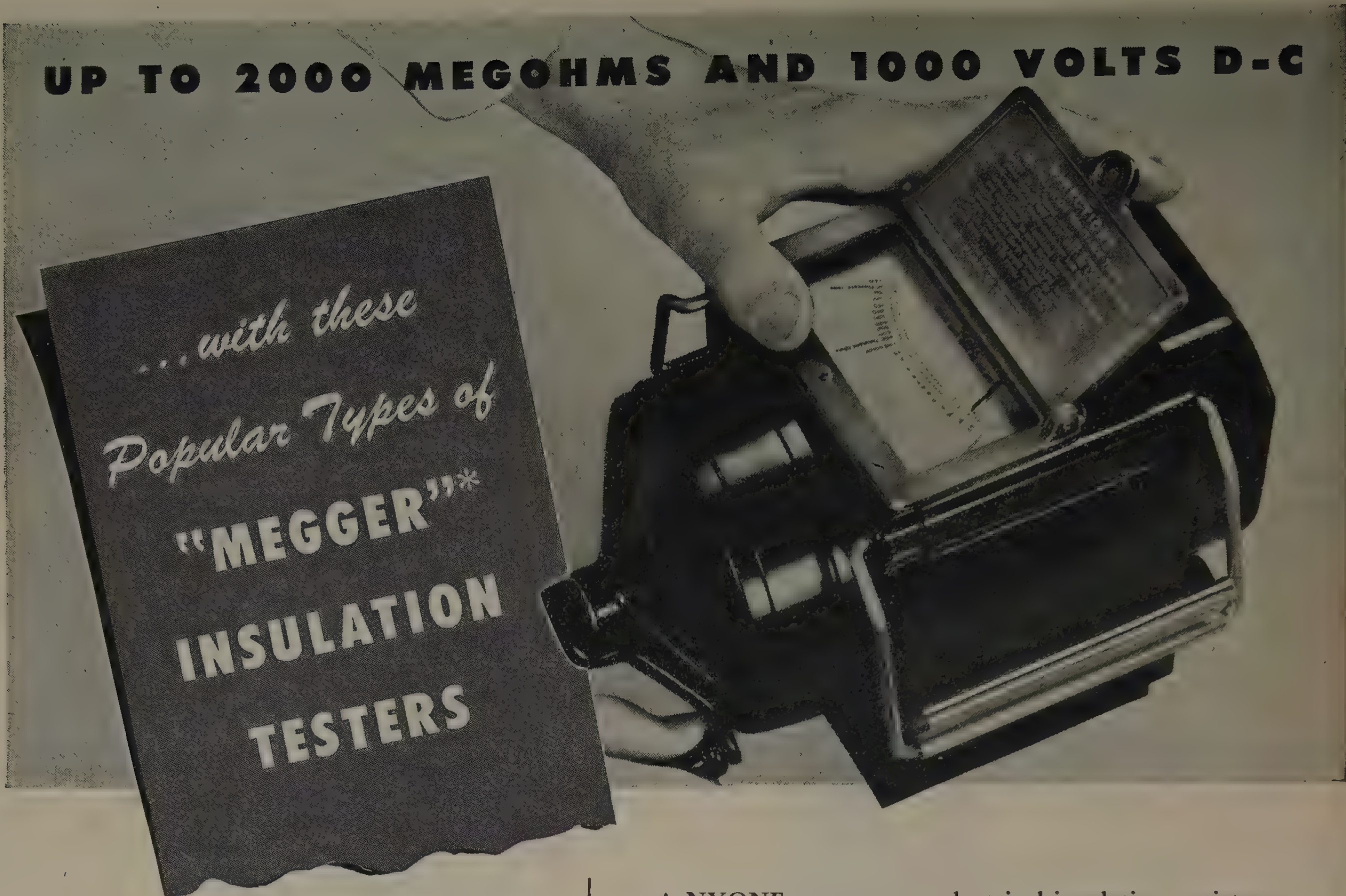


Mechanically and Electrically LAPP STATION POSTS Are The Choice For Switch and Bus Support At 115-161 Kv.

Shown above are a Lapp Station Post for 138-161 Kv, and a conventional pin-type station insulator of the same voltage. From the standpoint of rigidity and permanence compare the Station Post's six large-area low-intensity compression-loading cemented joints with the other design—twelve small-area high-intensity nested-porcelain joints. Which design do you think has the best chance of survival under stresses from thermal change, under torsion load, cantilever load and impact? Why would anybody specify the pin-type design when he can get the security of Lapp Station Posts—up to 161 Kv?

Lapp STATION POSTS

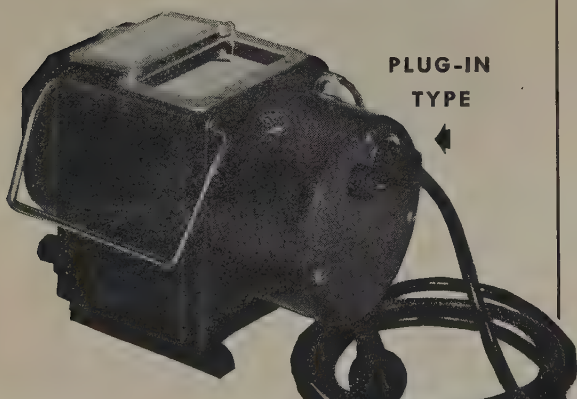
LAPP INSULATOR CO., INC. • LE ROY, N.Y., U. S. A.



ANYONE can measure electrical insulation resistance in generators, motors, wiring and other electrical equipment with a "Megger" Insulation Tester . . . quickly . . . easily. Merely make connections, turn the crank and read the position of the pointer on the scale.

The "Megger" instrument shown above consists essentially of a direct-reading ohmmeter mounted with a constant-voltage d-c hand generator in a rugged molded plastic case. It is conveniently small . . . can be easily carried by hand. It operates unfailingly, anywhere, anytime . . . without outside power supply or adjustments. And, it provides you with insurance against electrical failures.

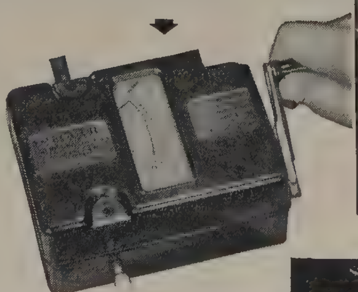
Other "Megger" Insulation Testers are available in various types with ratings up to 10,000 megohms and 2500 volts d-c. Write for descriptive illustrated Bulletin 21-45-EE.



PLUG-IN TYPE

● For those who need or prefer a "Megger" Insulation Tester that can be "plugged-in" instead of hand-cranked, we present the *rectifier-operated* instrument illustrated above. Simply connect to 115 volts a-c, flip a switch and proceed to make tests. It is especially useful where a number of tests are to be made at one time. A "power pack" consisting of a constant-potential step-up transformer and selenium rectifier, provides constant d-c test voltage. The "Megger" true ohmmeter covers a wide range and is independent of the supply voltage. A switch, pilot light and connecting cable are included. Available in various ratings up to 2000 megohms and 1000 volts. Ask for Bulletin 21-46-EE.

"MIDGET MEGGER" TESTER



. . . with the same essential features: used for detecting and diagnosing trouble in nearly all types of electrical equipment. Ratings up to 50 megohms and 500 volts variable voltage. It's a convenient answer to many of your electrical insulation problems. Write today for Bulletin 21-75-EE.

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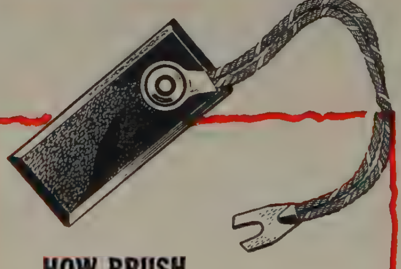
ALWAYS USE LENGTH ORIGINALLY RECOMMENDED!

DON'T just take a quick look at the worn brush stub as it comes from a machine and make a snap judgment as to the length of the replacement.

If you do, you'll soon have your inventory clogged with a variety of odd brush lengths. This means extra bins for storage, extra entries in your books, more complicated ordering, and more difficult maintenance.

Motors and generators are designed to use brushes of a certain carefully predetermined length. Shorter brushes wear out too soon. Longer brushes may throw the brush-spring pressure off center and cause faster initial wear. Use the lengths recommended for the equipment and you can't go wrong. And be sure to use "National" Carbon brushes. They are the best you can buy!



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GRADUATE ELECTRICAL ENGINEER, 17 years in public utility and industrial electrical design, maintenance and operation, chiefly on large substations and generating plants. Considerable experience administrative charge of engineering design. Desires similar work in progressive system, preferably hydroelectric. Address: Box 693, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

PRODUCTION ENGINEERING—Thirteen years industrial experience in all phases of plant operation assures efficient, practical handling of engineering, production, and quality control problems. Presently employed as Chief Production Engineer of Midwestern plant operating foundries, machining, assembly, galvanizing, plastics departments. Proven executive ability; adaptable, cooperative, responsible, diplomatic. BSEE, Reg. Prof. Engr., Member AIEE and ASQC. Age 36. California preferred. Address: Box 699, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

EXECUTIVE ENGINEER, B.E.E., age 40; 7 years experience testing and design integral horsepower AC and DC motors; 5 years experience in machine tool design and motor and control application to machinery, experienced in induction heat treating; 5 years executive consultant on motor and control application and plant engineering; Registered Professional Engineer. Desires responsible administrative or executive position. Minimum starting salary $10,000. Address: Box 700, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

DEVELOPMENT ENGINEER, broad background, electrical, electronic, mechanical; servos, auto. controls, etc. Excellent analytical ability. Seeks position as dept. head or assistant with moderate size company. Address: Box 701, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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GRADUATE ELECTRICAL ENGINEER, 23, 2 years industrial light and power experience, New York State Certificate of Engineer-in-Training of Professional License, willing to do moderate travel, seeks position as design and field engineer with company having staff for general industrial problems. Desire $4,000 per year start. Address: Box 703, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ENGINEERING SCHOOL in South has openings for a Professor of Electrical Engineering to teach graduate and undergraduate communications work ($6,000 for nine months, extra income for summer teaching, Ph.D. or D.Sc.) instructors ($2700 for nine months, extra income for summer teaching, B.S., may obtain M.S. in three years) and Graduate Assistants who may obtain M.S. in one year. ($1000 for nine months, extra income for summer teaching.) Address: Box 662, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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PLANT ENGINEER WANTED—Mechanical or Electrical Engineer with plant experience needed. Man with some experience in handling production problems and designing production equipment preferred. Good opportunity for the right man. Location, small town Western New York. Address: Box 705, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED—Graduate Electrical Engineer with experience in design, layout and maintaining electrical equipment and power distribution. Must be able to plan and direct the engineering of electrical work in Plant with 2,300 volt, 5,000 KW generation. Middle Eastern location. Address: Box 706, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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SOUTHWESTERN STATE COLLEGE engaged in research, development and operation in guided missile field has openings for graduate electrical engineers or physicists with experience in electro-mechanical devices, telemetering, audio, RF, VHF or antenna design. Salary depends on education and experience which should be fully described in first letter. Address: Box 707, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED, several engineering graduates, under 35, by large industrial fire prevention organization maintained by leading insurance group. Permanent position. Periodic inspections and special consulting service for leading industrial plants. Thorough training. Address: Box 709, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED. New or used. Crystal Mfg. Equipment, Finch Duplicators, Felker Model 80 Saws, Crystal Holders, Lapp Grinders, Crystal Blanks, Gen. Radio Freq. Standard, Electrodes, Vokel Grinders, Plating Equipment, and any other associated equipment used in the manufacture of crystals. Address: Box 711, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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Apply by letter addressed to the key number and mail to the New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

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ELEC ENGR, BEE cum laude; age 23; 1 1/3 yrs testg, des and developing elec instruments. Desires research or devpmt pos in servomechanisms or electronics. Prefers New York City or Long Island. E-384.

ELEC ENGR, proj management and controls for hvy pwr constr, reports, designs, investigations, estimates, procurement; seasoned exper best known companies; energy and initiative. Prefers New York City headquarters. E-385.

ELEC ENGR, grad; 44, married; exper in elec des, installation, maint, opern of util and indus pwr plants; also some substation des. Desires pos in pwr plant des, eqpt application, or indus plant engg. E-386.

Positions Available

EDITORIAL ASSISTANT, mechanical or electrical graduate, with industrial experience in power plant, refrigeration, pumping, etc., to prepare technical articles covering maintenance and operation of power plants and auxiliaries. Salary, $3600–$6000 a year. Location, New York, N. Y. Y-1509.

RESEARCH DIRECTOR, electrical engineering or physics graduate, with minimum of M.S. in nuclear physics and some biological training and experience, to take charge of laboratory specializing in use of radio-active substances in medical field. Salary, $8500 a year. Location, East. Y-1524.

TECHNICAL EDITOR, 30–35, mechanical or electrical graduate, with industrial equipment manufacturing, process or application experience, to solicit from design, development and production engineers articles of interest to readers of industrial periodicals and to edit these articles before submission to editors. Salary, $4200–$5200 a year. Location, western Pennsylvania, with occasional trips. Y-1535.

ASSISTANT ELECTRICAL ENGINEER, 25–30, graduate, with plant engineering experience, to design and lay out new electrical construction and assist in maintenance supervision of electrical equipment in process manufacturing plant. Salary, $3600–$4800 a year. Location, eastern Pennsylvania. Y-1544.

ELECTRICAL ENGINEER, graduate, with at least five years' laboratory research experience in electrical insulation field, to make research studies, investigate performance and write reports covering insulating materials. Salary, $4200–$6000 a year. Location, northern New Jersey. Y-1550.

ELECTRONIC ENGINEER, 30–40, with design and development experience on FM circuits, to supervise design and test of communication equipment. Salary, $6000–$7000 a year. Location, Brooklyn, N. Y. Y-1636.

PLANT ENGINEER, 40–45, preferably electrical graduate, with electrical maintenance experience in metal manufacturing industry including safety supervision, to take general charge of machine shop, stamping, plating, polishing, electronic heating, etc. Salary, $6000–$8000 a year. Location, northern New Jersey. Y-1644.

CHIEF ENGINEER, 35–50, electrical graduate, with considerable experience covering direction of engineering personnel, to take charge of design and development of industrial and governmental electronic program. Salary, $8000–$10,000 a year. Some traveling. Location, Washington, D. C. Y-1645.

RESEARCH ENGINEER, under 35, M.S. in E.E., to do research in the field of electronics. Should be capable of theoretical analysis and of creative thinking, to work on such problems as are assigned, and also to develop original problems of his own. Well-equipped electronics laboratories. Salary, $4500–$5000 a year, depending on experience, with one month vacation on pay. Location, West. Y-1658S.

ENGINEER, 30–40, graduate, electrical or mechanical, with experience in both, capable of meeting people, working up estimates and propositions, designing, detailing, if necessary, and following up in shop, by well established manufacturer of medium and heavy machinery for plywood and similar industries and marine deck machinery. Some travel necessary. Write giving qualifications, salary expected, etc. Location, New England. Y-1682.

DEVELOPMENT ENGINEER, electrical or mechanical graduate, with ceramic experience in electrical industry, for development project on dielectric condensers. Salary, $5000–$6000 a year. Location, Pennsylvania. Y-1689.

ELECTRONICS ENGINEER, under 50, with some experience in the development of measuring and controlling apparatus. Duties will be in connection with such development for aircraft instrumentation. Starting salary, $3900–$4800 a year. Location, Connecticut. Y-1706.

TRAINING INSTRUCTOR, electrical graduate, to teach electrical and electronic theory, prepare program of instruction, procuring necessary equipment and to teach a course in the field maintenance of electronic equipment; supervise four instructors engaged in teaching practical maintenance of equipment. Salary, $4479 a year. Location, Virginia. Y-1716.

INSTRUCTOR, recent graduate, in electrical engineering, to teach electronics, both class and laboratory, to undergraduates. Salary, $2700 for nine months, depending upon qualifications. Location, North Carolina. Y-1741.

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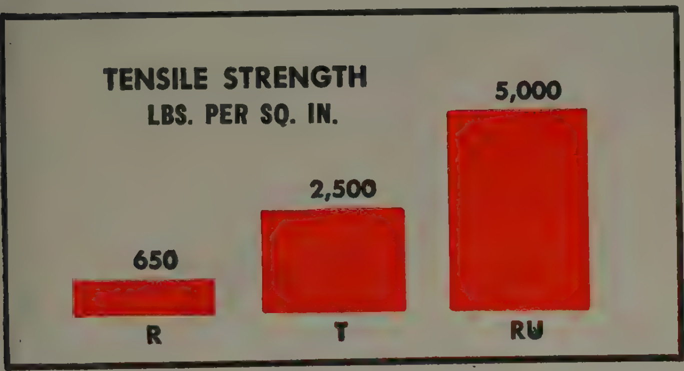
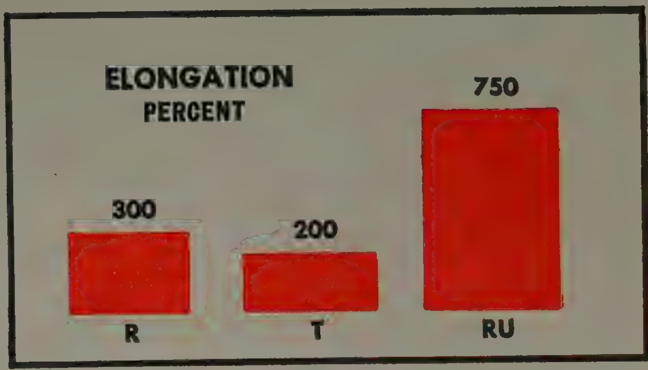
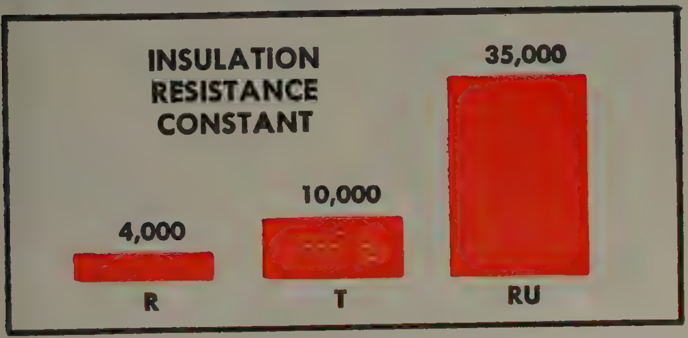
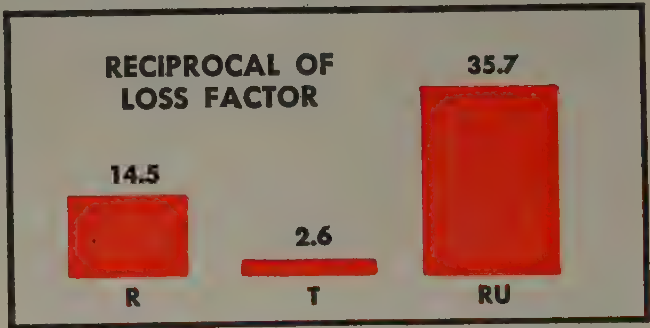
SMALLER DIAMETER CONTROL CABLES INSULATED WITH *Laytex**

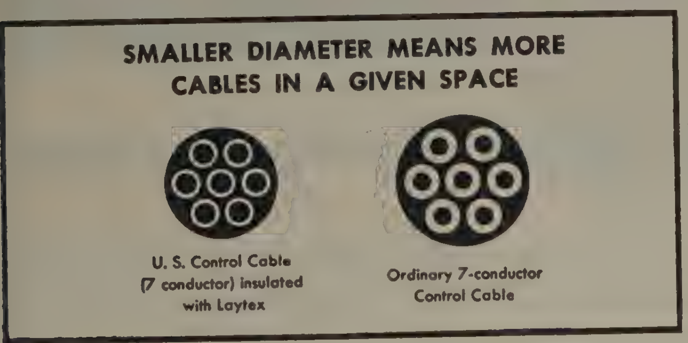
COMPARE *Laytex* ELECTRICALLY AND PHYSICALLY











Three common types of insulation used on the conductors of control cable are:

Type R—The copper conductor has a code rubber insulation.

Type T—A copper conductor with thermoplastic (a synthetic compound) insulation.

Type RU—LAYTEX. This type has a copper conductor, *natural rubber insulation.*

The charts above show the wide margin by which LAYTEX leads in physical and electrical qualities. It is one reason why U. S. Control Cables will continue, as in the past 16 years, to provide the finest service obtainable. For more information, write Wire and Cable Department, United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

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"8 Years of Constant High Temperatures

——— and our Rockbestos A.V.C. is Still Going Strong!"

Read HOW and WHY the Plant Engineer of a Large Rubber Company Specifies Permanently Insulated Wire and Cable for Hot-Spot Circuits.

"In 1940, when we revamped our boiler room, we rewired our lighting and power systems completely with Rockbestos A.V.C. wire and cable.

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"Where ordinary wire and cable gave us frequent trouble, Rockbestos A.V.C. gives entire satisfaction.

"Whenever we have need of wire or cable for use under extreme temperatures you can count on us specifying Rockbestos!"

This tested-in-service story is one of many which proves that you can protect your circuits by using the right wire for a tough job — specify Rockbestos A.V.C. Write for the new catalog showing all types.

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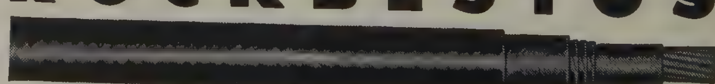


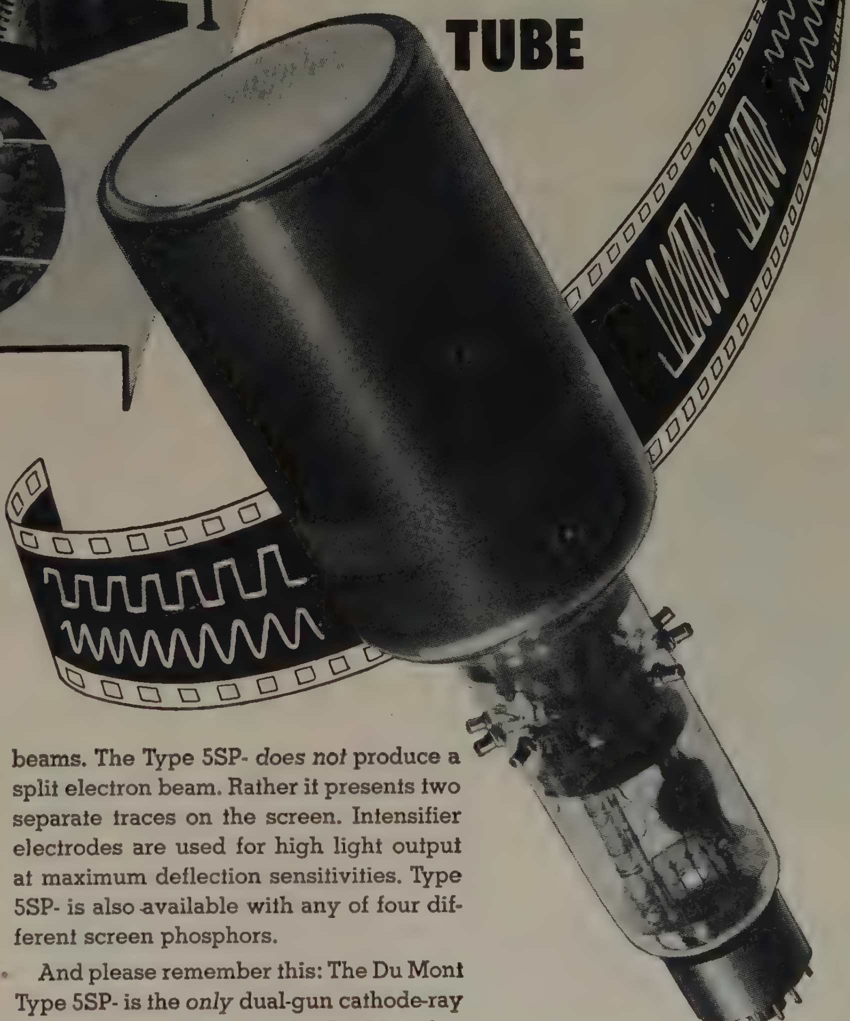
THE WIRE WITH PERMANENT INSULATION

To study the *simultaneous* characteristics of *any* device

THIS BIG...

or this small...

...use the DU MONT Type 5 SP- *Dual-beam* CATHODE-RAY TUBE



Both the concomitant electrical and/or *mechanical* characteristics of a piece of equipment may be conveniently examined and recorded with a Du Mont Type 5SP- Dual-beam Cathode-ray Tube. Especially so if used with a Du Mont Type 279 Dual-beam Cathode-ray Oscillograph.

For example: You can compare speed and vibration, velocity and acceleration. You can observe transient voltage and current; the input and output signals of amplifiers; related phenomena on different sweep frequencies; or again the complete signal and an expanded portion thereof. And for ease of recording, there is also available the Du Mont Type 314 Oscillograph-record Camera.

Indeed, the Type 5SP- is an unique cathode-ray tube since it embodies *two complete and independent* electron guns and deflection plate assemblies for the production of two entirely separate electron beams. The Type 5SP- *does not* produce a split electron beam. Rather it presents two separate traces on the screen. Intensifier electrodes are used for high light output at maximum deflection sensitivities. Type 5SP- is also available with any of four different screen phosphors.

And please remember this: The Du Mont Type 5SP- is the *only* dual-gun cathode-ray tube registered with the Radio Manufacturers Association.

Details on request.

DUMONT *for Oscillography*

ALLEN B. DU MONT LABORATORIES, INC., PASSAIC, N. J.
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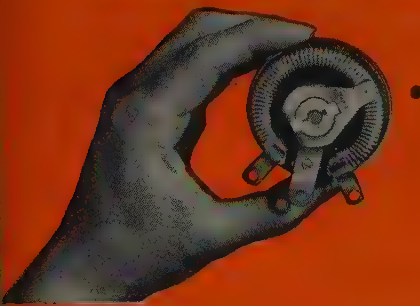
12-48

OHMITE Close Control RHEOSTATS



...Available with many additional features

On this page are shown some of the many forms in which standard Ohmite rheostats can be furnished. All models have the distinctive, time-proved features of Ohmite design. They are all-ceramic in construction—ceramic parts insulate the shaft and mounting, and the resistance winding is permanently locked in place by vitreous enamel. Smoothly-gliding, metal-graphite brush provides contact with every turn of the resistance winding. Ohmite rheostats are known for their smooth, gradual, close control and their long, trouble-free life.

Write for Catalog and Engineering Manual No. 40, on your letterhead. It contains information on the complete Ohmite line, plus a wealth of helpful engineering information.

Be Right with...

OHMITE

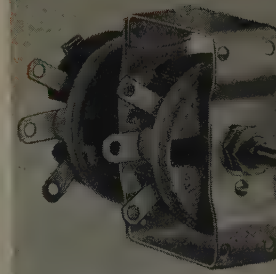
RHEOSTATS • RESISTORS
TAP SWITCHES

Industry's First Choice

OHMITE MANUFACTURING COMPANY
4803 Flournoy Street—Chicago 44, Illinois

TANDEM ASSEMBLIES

Ohmite rheostats can be mounted with two, three, or more in tandem, for simultaneous operation of several circuits by one knob.

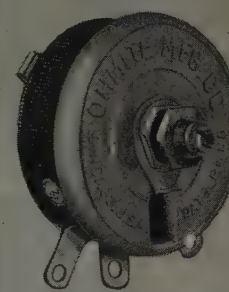


with BUSHINGS for special panel thickness

Rheostats can be furnished with extra-long bushings and shafts for panels over ¼″ and up to 2″ in thickness. Five bushing lengths.

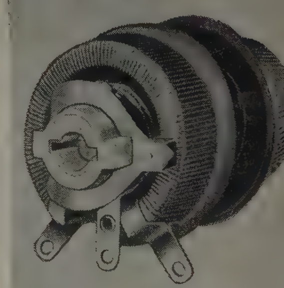
with SCREW DRIVER SLOT SHAFT

Shaft ends can be slotted for operation with a screwdriver, where few adjustments are needed. Minimizes tampering with setting.



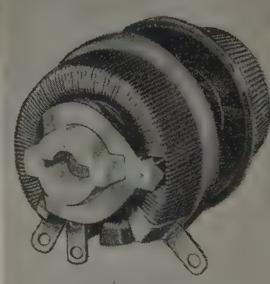
with DEAD LUG OFF-POSITION

Opens the circuit at the high resistance position as the contact passes on to the lug, which is disconnected from the winding.



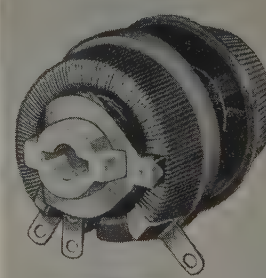
with SNAP-ACTION OFF POSITION

Opens the circuit at the high or low resistance position. The contact brush snaps into an insulated notch next to the lug, providing indexing.



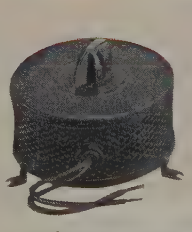
with DEAD-SECTION OFF POSITION

Opens the circuit at the high or low resistance position as the brush passes off the lug onto an insulated section. Medium duty.



in TABLE MOUNTING CAGES

Used to prevent mechanical injury to the rheostat or human contact with electrically "live" parts. Tabletop mounting, ventilated enclosures.

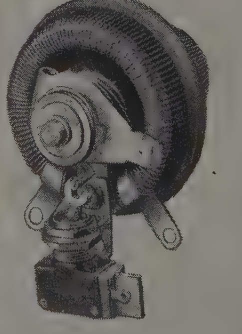


with TOGGLE SWITCH and EXTRA LUG

Permits dual switching of rheostat and independent circuits. Rheostat winding is terminated at an extra lug located where the switch opens.

with TOGGLE SWITCH

Toggle switch is operated with a positive snap by the rheostat arm at either end position. Used for heavy duty applications.



INDEX TO ADVERTISERS

NOW... Selective tripping accomplished more effectively, more dependably with direct-acting

I-T-E SELECTIVE OVERCURRENT TRIP DEVICE ®

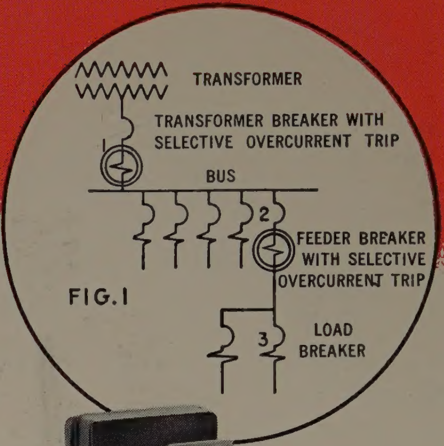


FIG. I

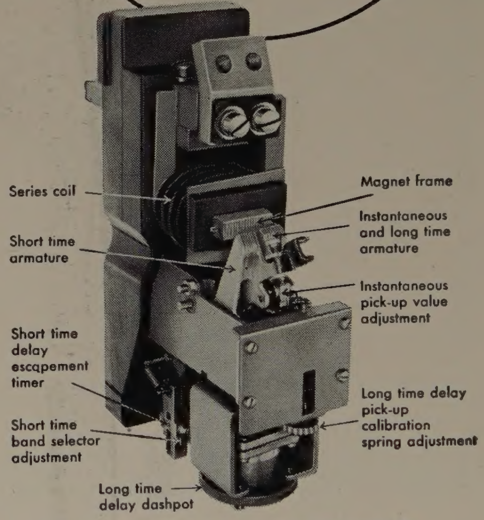
SELECTIVE TRIPPING is a scheme for applying circuit breakers in series, so that fault currents in a distribution system are interrupted only by the breaker *closest to the fault*. Through Selective Tripping, maximum continuity of service is maintained after interruption of a feeder-fault.

Now, through the use of I-T-E's *direct-acting* Selective Overcurrent Trip Device, originated by I-T-E engineers, Selective Tripping has reached a new high in effectiveness and dependability. Through its direct action, the Device is more reliable because it eliminates the need for control circuits and costly auxiliary control equipment. Being mounted right on the breaker, it is space-saving, readily accessible, and economical to maintain.

If you are planning the installation or modernization of any industrial or central station electrical distribution system, it will pay you to investigate the possibilities of a Selective Tripping scheme utilizing I-T-E Air Circuit Breakers with the exclusive I-T-E Selective Overcurrent Trip Device. The I-T-E representative in your locality will be glad to assist and advise you. We will furnish names and details of prominent Selective Tripping installations using I-T-E equipment upon request.

TYPICAL OPERATION

This device operates through a series coil with two clapper-type armatures mounted side by side. One armature is connected to a long-time delay and has a pick-up point of 80–160%. This long-time armature is connected to its timer through a calibrated spring which permits instantaneous tripping when the current reaches a predetermined value above 1200%. The second armature is connected to a short-time delay escapement mechanism, and has a pick-up value of 800–1200% of the rated coil current. In operation, both armatures start moving at the current values for which they are calibrated. Thus, if the current is above instantaneous value, both timers start moving, but precedence in tripping is obtained by the instantaneous armature due to the yield of the calibrated spring. If the current is in the short-time range, both armatures move, but the short-time armature trips the breaker before the long-time armature has moved very much. The difference in the short-time tripping ranges of the breakers in the system is so arranged that the breaker farthest from the source of power trips first.



I-T-E SELECTIVE OVERCURRENT TRIP DEVICE ®
(Elementary type used for purposes of operation explanation only)

For a complete technical explanation of Selective Tripping, write for Bulletin 4802, SELECTIVE TRIPPING OF LOW VOLTAGE AIR CIRCUIT BREAKERS.

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